KX022 and KX023 Supplemental Offset Calibration

Introduction

Kionix calibrates the offset of the KX022 and KX023 at the factory. After assembly, it is sometimes found by the customer that there is a subsequent offset shift.

The KX022 and KX023 have embedded registers used to provide a final factory calibration. These registers have the default factory calibration but also they can be adjusted by a user programmatically for an additional offset adjustment to the original factory programmed calibration.

The values for the user applied offset adjustment are stored in RAM and must be updated by the controlling system after each power up or reset.

Offset Calibration readings and adjustments are calculated using 2g High RES mode.

The Offset calibration adjustment adds a constant value to correct for an offset error.

Two registers are employed to make the Offset Calibration adjustment.

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Offset Calibration Registers:

The offset correction registers XCAL (1Dh), YCAL(1Eh), and ZCAL (1Fh) are located on memory page 1 and not memory page 0.
To write to the calibration registers simply write 0x01h to address 0x7Fh to switch to memory page 1.
Then write your correction values for XCAL, YCAL and ZCAL registers.
Switch back to memory page 0 by writing 0x00h to address 0x7Fh

OUT_CNTL

Output Data Control

Register	Page	Addr	R/W	Default	Bit 7	Bit 6	Bit 5	Bit 4	Bit3	Bit 2	Bit 1	Bit 0
OUT_CNTL	01h	1Ch	R/W	OTP	RSVD	RSVD	RSVD	RSVD	0	0	CALRES<1>	CALRES<0>

CALRES<1:0> *- Digital calibration resolution select*
00 = 0.24mg/count
01 = 0.48mg/count
10 = 0.96mg/count
11 = 1.92mg/count

The Output Data Control Register allows for a choice between the range and the resolution of the Offset adjustment correction value.

Accelerometer digital offset calibration

Register	Page	Addr	R/W	Default	Bit 7	Bit 6	Bit 5	Bit 4	Bit3	Bit 2	Bit 1	Bit 0
XCAL	01h	1Dh	R/W	OTP	XCAL<7>	XCAL<6>	XCAL<5>	XCAL<4>	XCAL<3>	XCAL<2>	XCAL<1>	XCAL<0>
YCAL	01h	1Eh	R/W	OTP	YCAL<7>	YCAL<6>	YCAL<5>	YCAL<4>	YCAL<3>	YCAL<2>	YCAL<1>	YCAL<0>
ZCAL	01h	1Fh	R/W	OTP	ZCAL<7>	ZCAL<6>	ZCAL<5>	ZCAL<4>	ZCAL<3>	ZCAL<2>	ZCAL<1>	ZCAL<0>

Offset_cal<7:0>: This offset is in 2s compliment format and is added to the output value. Digital calibration resolution can be selected via CALRES1 and CALRES0 bits in OUT_CNTL register.

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Examples

There are two ways that one can alter the Offset of the KX023 post assembly. The factory calibration is stored in the Non-Volatile memory and must be overwritten in RAM.

A) Leave the default factory settings in place and measure the post assembly offset error. Then read the factory setting, add the post assembly error to the factory setting and then write the new value to the RAM registers upon power up.

B) Setting a zero (b00000000) to the XCAL (likewise for YCAL and ZCAL), thus eliminating the factory calibration, and then measure the resulting offset error. Then calculate the correction value in both the CALRES and XCAL (Y and Z also) and then write those values to the RAM registers.

Procedure "A"

If at the end of assembly of a product which includes the KX022 or KX023 it is found that the part registers an X Offset error of 5 mg.

The Offset can be corrected subsequent to power up in the Volatile memory.

1. Read the OUT_CNTL register to determine the default factory register setting and the resolution of the CALRES, e.g. b01 (bits 0 and 1) for this example is 0.48 mg/count. The CALRES register is used for more than just the calibration resolution so (reserved) bits 2, 3, 4, 5, 6, 7 must be read and used and rewritten along with new values for bits 0 and 1. The OUT_CNTL register bits 2-7 are not variable and can be stored in a controller memory instead of repeated readings.
2. Read the XCAL to find the default factory setting, for example b00010001 or 17 counts at 0.48 mg/count, or 8 mg of factory correction written in permanent memory.
3. Measure the post assembly offset error without changing the factory calibration.
4. A post assembly offset error is found to be 5 mg. This value is the deviation from the factory calibration.
5. The sum of 8 mg of factory calibration and 5 mg of post assembly error add to 13 mg or needed correction. At the lowest CALRES of 0.24mg/count one calculates the correction to be 13 (mg) / 0.24 (mg/count) = 54 COUNTS of correction. The user can change the CALRES to CALRES = 00. If the total had exceeded 127 counts (or -128 for 2s compliment), then a higher CALRES value would be required.
6. Set PC1 = 0 to make any changes to Volatile memory.
7. Set the OUT_CNTL register to match the bits 2-7 found in step 1 along with the updates for bits 0 and 1 to select the resolution of the CALRES to 0.24 mg/Count, or "00" for bits 0 and 1.

8. Then set XCAL to b00110110 (54 counts).
9. The values for OUT_CNTL and XCAL, YCAL, ZCAL loaded in RAM will be lost once the part is powered off, so the write to Volatile memory must be repeated upon each power up. The values may be stored in the controller memory for repeated use.

Procedure "B"

Procedure B is very similar to procedure A except that the XCAL (Y and Z) is written with zeroes to eliminate the factory calibration. Thus when the post assembly offset error is read it will indicate the total actual offset error.

1. Set PC1 = 0 (disable) to make any changes to Volatile memory.
2. Write 00000000 to XCAL, YCAL, and ZCAL in RAM.
3. Set PC1 = 1 (enable)
4. Measure the total post assembly offset error.
5. Calculate and adjust the CALRES as needed and adjust the XCAL, YCAL and ZCAL as needed. (as described in procedure "A") Be sure to first read OUT_CNTL bits 2 through 7 to write them back when updating the CALRES values of OUT_CNTL bits 0 and 1.
6. Set PC1 = 0 to make any changes to Volatile memory.
7. Write changes to registers.

The offset correction is applied at the lowest level of the sensor digital conversion as will be in effect for all engines.

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/parametric/Accelerometers.