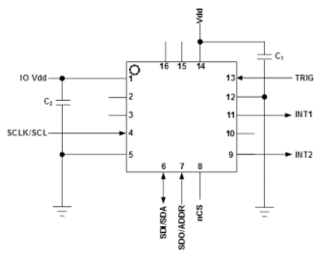
Introduction

The purpose of this application note is to illustrate how the Kionix KXG07 accelerometer-gyroscope can replace an existing Kionix KX023, KX123, or KX124 accelerometer.

Pin Compatibility

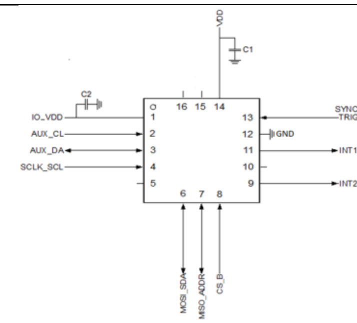
The KX023, KX123, and KX124 accelerometer can easily be replaced by a KXG07 accelerometer-gyroscope for either an I2C or SPI interface application. In some existing KX023, KX123, and KX124 applications; the KXG07 may be drop in replaceable (hardware only).

KX023, KX123, and KX124



Pin	Name	Description
1	IO_VDD	The power supply input for the digital communication bus. Optionally decouple this pin to ground with a 0.1uF ceramic capacitor.
2	NC	Not Internally Connected – Can be connected to VDD, IO_VDD, GND or leave floating
3	NC	Not Internally Connected – Can be connected to VDD, IO_VDD, GND or leave floating
4	SCLK/SCL	SPI and I^{2}C Serial Clock
5	GND	Ground
6	SDI/SDA	SPI Data input / I2C Serial Data
7	SDO/ADDR	Serial Data Out pin during 4 wire SPI communication and part of the device address during I2C communication.
8	nCS	SPI enable / I2C mode select. Connect to GND for SPI enabled, I2C communication disabled. Connect to IO_VDD for SPI disabled, I2C communication enabled. Do not leave floating.
9	INT2	Physical Interrupt 2. Leave floating if not used.
10	NC	Not Internally Connected – Can be connected to VDD, IO_VDD, GND or leave floating
11	INT1	Physical Interrupt 1. Leave floating if not used.0
12	GND	Ground
13	TRIG	Trigger pin for FIFO buffer control – Connect to GND when not using external trigger option.
14	VDD	The power supply input. Decouple this pin to ground with a 0.1uF ceramic capacitor.
15	NC	Not Internally Connected – Can be connected to VDD, IO_VDD, GND or leave floating
16	NC	Not Internally Connected – Can be connected to VDD, IO_VDD, GND or leave floating

KXG07



Pin	Name	Description
1	VDDIO	External supply for IO ring. Optional Bypass capacitor C2
2	AUX_CL	Auxiliary I2C master serial clock.
3	AUX_DA	Auxiliary I2C master serial data.
4	SCLK_SCL	SPI/I2C serial clock.[1]
5	NC	Leave unconnected or connect to GND
6	MOSI_SDA	SPI MOSI / I2C serial data. [1]
7	MISO_ADDR	SPI MISO / I2C slave_addr[0]
8	CS_B	SPI mode CS_B = 0 / I2C mode CS_B = 1
9	INT2	Programmable interrupt output.[2]
10	NC	Leave unconnected or connect to GND or IO_VDD
11	INT1	Programmable interrupt output.
12	VSS	GND.
13	SYNC_TRIG	SYNC input/output. External TRIG input for buffer function.[2,3]
14	VDD	External supply with Bypass capacitor C1
15	NC	Leave unconnected or connect to GND
16	NC	Leave unconnected or connect to GND

Figure 1: Pin Description KX023, KX123, and KX124 vs. KXG07

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Key Differences

- KXG07 additionally offers:
  - Accelerometer-Gyroscope combination (6-axis)
  - Temperature sensor
  - Timestamping
  - Larger sample buffer (4096 bytes)
  - ±16g Full Scale range selection
  - Auxiliary I2C master interface to control up to 2 additional auxiliary sensors
- KXG07 internal register definitions do not align exactly with the KX023/123/124. Since the KXG07 contains the same engines within the KX023/123/124, many of the register names are the same (bit locations may differ). Software changes are required in the user's application.
- KXG07 (highlighted notes 2, 3 in Figure 1):
  - Care must be taken with external connection of the SYNC pin. The reset state of the SYNC pin is tri-stated. If pin is not used in application, connect to IO_VDD or GND and ensure the state of the pin is never changed to output through register write to FSYNC_CTL register. If pin is configured as Output in the application, the pin must be left floating to avoid internal short circuit to IO_VDD or GND.
  - The INT2 and SYNC_TRIG pins are multifunction pins. The pin configuration changes based on the state of fsync_trig and fsync_mode[1:0] control fields per below table:

fsync_trig	fsync_mode	INT2	SYNC_TRIG	Notes
0	0	interrupt 2	trigger	Fsync function is not enabled.
0	>0	interrupt 2	sync	Fsync function is enabled.
1	x	sync	trigger	

Figure 2: Multifunctional Pin Operation

Side-by-Side Comparison

The following are key similarities and differences in hardware and software between the KX023, KX123, KX124 accelerometer and the KXG07 accelerometer-gyroscope:

Package Information

Parameter	Units	KX023	KX123	KX124	KXG07
Sensing Axis (Accel)		XYZ 3-axis	XYZ 3-axis	XYZ 3-axis	XYZ 3-axis
Sensing Axis (Gyro)					XYZ 3-axis
Package Size	mm	3x3x0.9	3x3x0.9	3x3x0.9	3x3x0.9
Package Type		LGA	LGA	LGA	LGA
Pins		16	16	16	16

Features

Parameter	Units	KX023	KX123	KX124	KXG07
Low Power Mode		Yes	Yes	Yes	Yes
Self-test		Yes	Yes	Yes	Yes
Wake-up		Yes	Yes	Yes	Yes
Back-to-Sleep		Yes	Yes	Yes	Yes
Freefall Detection		Yes	Yes	Yes	Yes
Tap, Double Tap Detection		Yes	Yes	Yes	Yes
Tilt Orientation Detection		Yes	Yes	Yes	Yes
Sample Buffer (FIFO)	Bytes	256	2048	2048	4096
Accelerometer Sensor		Yes	Yes	Yes	Yes
Temperature Sensor		No	No	No	Yes
Gyroscope		No	No	No	Yes
Timestamp		No	No	No	Yes
Auxiliary I2C		No	No	No	Yes

Electrical Specifications

Parameter			Units	KX023	KX123	KX124	KXG07
Supply Voltage (Vdd)			V	1.71–3.6	1.71–3.6	1.71–3.6	1.71–3.6
I/O Pads Supply Voltage (IOVdd)			V	1.7–Vdd	1.7–Vdd	1.7–Vdd	1.7–Vdd
Current Consumption	Low Power	Operating (Accel Only)	µA	10	10	10	15
		Operating (Gyro Only)	µA				185
		Operating (Gyro + Accel)	µA				200
	High Res	Operating (Accel Only)	µA	145	145	145	150
		Operating (Gyro Only)	µA				500
		Operating (Gyro + Accel)	µA				600
	Standby		µA	0.9	0.9	0.9	1.5
I2C Communication Rate (max)			MHz	3.4	3.4	3.4	3.4
SPI Communication Rate (max)			MHz	10	10	10	10

Environmental

Parameter	Units	KX023	KX123	KX124	KXG07
Supply Voltage (VDD)	V	-0.3–3.63	-0.3–3.63	-0.3–3.63	-0.3–3.6
Operating Temperature Range	°C	-40–85	-40–85	-40–85	-40–85
Storage Temperature Range	°C	-55–150	-55–150	-55–150	-55–150
Mechanical Shock (powered and unpowered)	g	5000 for 0.5ms 10000 for 0.2ms	5000 for 0.5ms 10000 for 0.2ms	5000 for 0.5ms 10000 for 0.2ms	5000 for 0.5ms 10000 for 0.2ms
ESD (HBM)	V	2000	2000	2000	2000

Accelerometer Mechanical

Parameter		Units	KX023	KX123	KX124	KXG07
Operating Temperature Range		°C	-40–85	-40–85	-40–85	-40–85
Zero-g Offset		mg	±25	±25	±25	±25
Zero-g Offset Variation from RT over Temp.		± mg/ºC	0.2	0.2	0.2	0.25
Sensitivity	GSEL1=0, GSEL0=0 (±2g)	counts/g	16384	16384	16384	16384
	GSEL1=0, GSEL0=1 (±4g)	counts/g	8192	8192	8192	8192
	GSEL1=1, GSEL0=0 (±8g)	counts/g	4096	4096	4096	4096
	GSEL1=1, GSEL0=1 (±16g)	counts/g				2048
Sensitivity Variation from RT over Temp.		%/°C	0.01	0.01	0.01	0.01 (xy) 0.03 (z)
Self-Test Output change on Activation		g	0.5	0.5	0.5	0.5
Mechanical Resonance (-3dB)[1]		Hz	3500 (xy) 1800 (z)	3500 (xy) 1800 (z)	3500 (xy) 1800 (z)	3500 (xy) 1800 (z)
Non-Linearity		% of FS	0.6	0.6	0.6	0.5
Cross Axis Sensitivity		%	2	2	2	2
Noise (RMS at 50Hz)		mg	0.75	0.75	0.75	TBD

1. Resonance as defined by the dampened mechanical sensor.

Sensor Output Registers (Primary)

Addr (hex)	KX023, KX123, KX124		KXG07	
	Name	Description	Name	Description
00	XHP_L	X-axis high pass filter output low	TEMP_OUT_L	Temperature output low byte
01	XHP_H	X-axis high pass filter output high	TEMP_OUT_H	Temperature output high byte
02	YHP_L	Y-axis high pass filter output low	GYRO_XOUT_L	Gyro X-axis output low byte
03	YHP_H	Y-axis high pass filter output high	GYRO_XOUT_H	Gyro X-axis output high byte
04	ZHP_L	Z-axis high pass filter output low	GYRO_YOUT_L	Gyro Y-axis output low byte
05	ZHP_H	Z-axis high pass filter output high	GYRO_YOUT_H	Gyro Y-axis output high byte
06	XOUT_L	X-axis output low	GYRO_ZOUT_L	Gyro Z-axis output low byte
07	XOUT_H	X-axis output high	GYRO_ZOUT_H	Gyro Z-axis output high byte
08	YOUT_L	Y-axis output low	ACC_XOUT_L	Accel X-axis output low byte
09	YOUT_H	Y-axis output high	ACC_XOUT_H	Accel X-axis output high byte
0A	ZOUT_L	Z-axis output low	ACC_YOUT_L	Accel Y-axis output low byte
0B	ZOUT_H	Z-axis output high	ACC_YOUT_H	Accel Y-axis output high byte
0C			ACC_ZOUT_L	Accel Z-axis output low byte
0D			ACC_ZOUT_H	Accel Z-axis output high byte

The Kionix Advantage

Kionix technology provides 6 Degrees-of-Freedom inertial sensor system on a single, silicon chip, which is designed to strike a balance between current consumption and noise performance with excellent bias stability over temperature. A gyroscope 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
Remote controls
Toys

Theory of Operation

During operation, the gyroscope sensor elements are forced into vibration. When angular velocities are applied about the sensing axes, vibration is transferred to sensing elements, causing capacitance changes at the sensor electrodes. Acceleration sensing is based on the principle of a differential capacitance arising from acceleration-induced motion of the sense element, which utilizes common mode cancellation to decrease errors from process variation, temperature, and environmental stress. Capacitance changes are amplified and converted into digital signals which are processed by a dedicated digital signal processing unit. The digital signal processor applies filtering, bias and sensitivity adjustment, as well as temperature compensation. The DSP also feeds back the driving signal to ensure the proper sensor excitation.

For product summaries, specifications, and schematics, please refer to the Kionix MEMS accelerometer product catalog at http://www.kionix.com/parametric/6-Axis Combo Parts And 9-Axis Solutions