Introduction

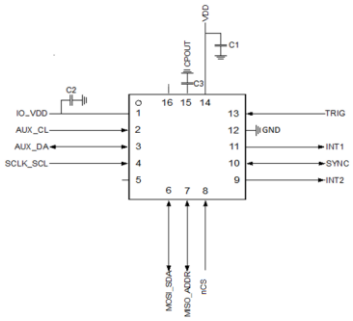
The purpose of this application note is to illustrate how the Kionix KXG07/KXG08 accelerometer-gyroscope can replace an existing Kionix KXG03 accelerometer-gyroscope.

Pin Compatibility

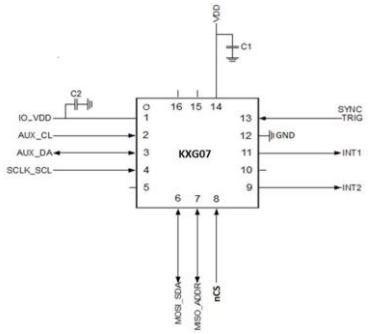
KXG03 to KXG07

The KXG03 accelerometer-gyroscope can easily be replaced by a KXG07 accelerometer-gyroscope for either an I^2C or SPI interface application.

KXG03



KXG07



Pin	Name	Description
1	IO_VDD	External supply for IO ring. Connect 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
5	RESERVED	Connect to GND or leave floating. Do not connect to IO_VDD.
6	MOSI_SDA	SPI MOSI / I2C serial data
7	MISO_ADDR	SPI MISO / I2C slave_addr[0]
8	nCS	SPI enable / I2C mode select (GND=SPI enabled, I2C communication disabled / IO_VDD=SPI disabled, I2C communication enabled). In SPI communication – needs to be tied to nCS pin of the host.
9	INT2	Programmable interrupt output
10	SYNC	Sync input or output. If configured as input, connect to IO_VDD or GND. If configured as output, leave floating.
11	INT1	Programmable interrupt output
12	GND	Ground
13	TRIG	External trigger input for buffer actions. Connect to IO_VDD or GND if unused.
14	VDD	External supply with bypass capacitor C1
15	CPOUT	External charge pump reservoir cap C3
16	RESERVED	Connect to GND or leave floating

Pin	Name	Description
1	IO_VDD	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
5	NC	Leave unconnected or connect to GND
6	MOSI_SDA	SPI MOSI / I2C serial data.
7	MISO_ADDR	SPI MISO / I2C slave_addr[0]
8	nCS	SPI mode nCS = GND / I2C mode nCS = IO_VDD. In SPI communication – needs to be tied to nCS pin of the host
9	INT2	Programmable interrupt output.
10	NC	Leave unconnected or connect to GND or IO_VDD
11	INT1	Programmable interrupt output.
12	GND	GND
13	SYNC_TRIG	SYNC input/output. External TRIG input for buffer function.
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 KXG03 vs. KXG07

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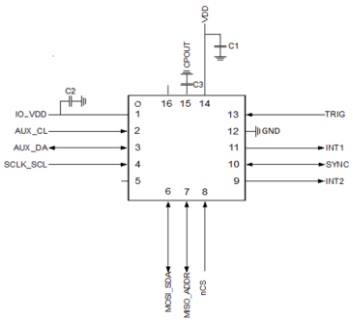
KXG03 to KXG08

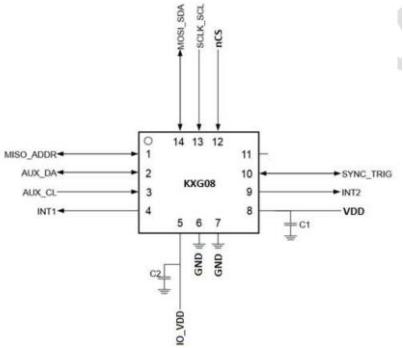
The KXG03 accelerometer cannot easily be replaced by a KXG08 accelerometer-gyroscope for either an I²C or SPI interface application, due the package size. As a result, existing layout and routing modifications are necessary.

KXG03



Pin	Name	Description
1	IO_VDD	External supply for IO ring. Connect 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
5	RESERVED	Connect to GND or leave floating. Do not connect to IO_VDD.
6	MOSI_SDA	SPI MOSI / I2C serial data
7	MISO_ADDR	SPI MISO / I2C slave_addr[0]
8	nCS	SPI mode nCS = GND / I2C mode nCS = IO_VDD. In SPI communication – needs to be tied to nCS pin of the host
9	INT2	Programmable interrupt output
10	SYNC	Sync input or output. If configured as input, connect to IO_VDD or GND. If configured as output, leave floating.
11	INT1	Programmable interrupt output
12	GND	Ground
13	TRIG	External trigger input for buffer actions. Connect to IO_VDD or GND if unused.
14	VDD	External supply with bypass capacitor C1
15	CPOUT	External charge pump reservoir cap C3
16	RESERVED	Connect to GND or leave floating

KXG08



Pin	Name	Description
1	MISO_ADDR	SPI MISO / I2C slave_addr[0]
2	AUX_DA	Auxiliary I2C master serial data
3	AUX_CL	Auxiliary I2C master serial clock
4	INT1	Programmable interrupt output
5	IO_VDD	External supply for IO ring. Optional Bypass capacitor C2
6	GND	GND
7	GND	GND
8	VDD	External supply with Bypass capacitor C1
9	INT2	Programmable interrupt output
10	SYNC_TRIG	SYNC input/output. External TRIG input for buffer function.2,3
11	NC	Leave unconnected
12	nCS	SPI mode nCS = GND / I2C mode nCS = IO_VDD. In SPI communication – needs to be tied to nCS pin of the host
13	SCLK_SCL	SPI/I2C serial clock.
14	MOSI_SDA	SPI MOSI / I2C serial data.

Figure 2: Pin Description KXG03 vs. KXG08

Key Differences

- KXG07/KXG08 additionally offer:
  - Timestamping
  - Freefall Detection
  - Tap, Double Tap Detection
  - Tilt Orientation Detection
  - Larger sample buffer (4096 bytes)
  - Additional User Selectable Gyroscope Full Scale Ranges: ±64 deg/s, ±128 deg/s, while still offering ±256 deg/s, ±512 deg/s, ±1024 deg/s, ±2048 deg/s,
- KXG07/KXG08 do not offer separate sleep / wake control, meaning you cannot have separate ODRs, ranges, etc. for sleep / wake modes.
- KXG07/KXG08 internal register definitions do not align exactly with the KXG03. Since the KXG07/KXG08 contains some features that existed on the KXG03, some of the register names are the same (bit locations may differ). Software changes are required in the user's application.
- KXG07/KXG08 (highlighted notes 2, 3 in Figure 1 and Figure 2):
  - 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 3: Multifunctional Pin Operation

Side-by-Side Comparison

The following are key similarities and differences in hardware and software between the KXG03 accelerometer and the KXG07/KXG08 accelerometer-gyroscope:

Package Information

		KXG03	KXG07	KXG08
Parameter	**Units**			
Sensing Axis (Accel)		XYZ 3-axis	XYZ 3-axis	XYZ 3-axis
Sensing Axis (Gyro)		XYZ 3-axis	XYZ 3-axis	XYZ 3-axis
Package Size	mm	3x3x0.9	3x3x0.9	3x2.5x0.9
Package Type		LGA	LGA	LGA
Pins		16	16	14

Features

		KXG03	KXG07/KXG08
Parameter	**Units**		
Low Power Mode		Yes	Yes
Self-test		Yes	Yes
Wake-up		Yes	Yes
Back-to-Sleep		Yes	Yes
Freefall Detection		No	Yes
Tap, Double Tap Detection		No	Yes
Tilt Orientation Detection		No	Yes
Sample Buffer (FIFO)	Bytes	1024	4096
Accelerometer Sensor		Yes	Yes
Temperature Sensor		Yes	Yes
Gyroscope		Yes	Yes
Timestamp		No	Yes
Auxiliary I2C		Yes	Yes

Electrical Specifications

				KXG03	KXG07/KXG08
Parameter			**Units**		
Supply Voltage (VDD)			V	1.8 – 3.3	1.71 – 3.6
I/O Pads Supply Voltage (IO_VDD)			V	1.7 – VDD	1.35 – 3.6
Current Consumption	Low Power	Operating (Accel Only)	µA	5	15
		Operating (Gyro Only)	µA		185
		Operating (Gyro + Accel)	µA		200
	High Res	Operating (Accel Only)	µA	250	150
		Operating (Gyro Only)	mA	1.85	500
		Operating (Gyro + Accel)	mA	2.1	600
	Standby		µA	1.5	1.5
I2C Communication Rate (max)			MHz	3.4	3.4
SPI Communication Rate (max)			MHz	10	10

Environmental

Parameter	Units	KXG03	KXG07/KXG08
Supply Voltage (VDD) – Absolute Limits	V	-0.3 – 3.6	-0.3 – 3.6
Operating Temperature Range	°C	-40 – 85	-40 – 85
Storage Temperature Range	°C	-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
ESD (HBM)	V	2000	2000

Gyroscope Mechanical

Parameter		Units	KXG03	KXG07/KXG08
Operating Temperature Range		°C	-40 – 85	-40 – 85
Zero Rate Output, Digital		counts	0	0
Zero Rate Output Stability		± % of FS	1	1
Zero Rate Output Variation over Temperature		± deg/sec	5	5
Sensitivity	±64 deg/sec	counts/deg/sec		512
	±128 deg/sec	counts/deg/sec		256
	±256 deg/sec	counts/deg/sec	128	128
	±512 deg/sec	counts/deg/sec	64	64
	±1024 deg/sec	counts/deg/sec	32	32
	±2048 deg/sec	counts/deg/sec	16	16
Sensitivity Variation over Temperature		%	5	1.5
Noise Density		deg/sec/√Hz	0.03	0.03
Output Noise (6.25 Hz BW)		dps-rms	0.23	0.094
Non-Linearity		% of FS	0.5	0.5
Cross Axis Sensitivity		± %	1	1
Bandwidth		Hz	10–160	ODR/2 or ODR/9

Accelerometer Mechanical

			KXG03	KXG07/KXG08
Parameter		**Units**		
Operating Temperature Range		°C	-40 - 85	-40 - 85
Zero-g Offset		± mg	25	25
Zero-g Offset Variation from RT over Temp		± mg/ºC	0.2	0.25
Sensitivity	GSEL1=0, GSEL0=0 (±2g)	counts/g	16384	16384
	GSEL1=0, GSEL0=1 (±4g)	counts/g	8192	8192
	GSEL1=1, GSEL0=0 (±8g)	counts/g	4096	4096
	GSEL1=1, GSEL0=1 (±16g)	counts/g	2048	2048
Sensitivity Variation from RT over Temp		%/°C	0.01	0.01 (xy) 0.03 (z)
Self-Test Output change on Activation		g	0.5	0.5
Mechanical Resonance (-3dB)		Hz	3500 (xy) 1800 (z)	3500 (xy) 1800 (z)
Non-Linearity		% of FS	0.6	0.5
Cross Axis Sensitivity		%	2	2
Noise Density		µg/ √ (Hz)	150	150
Bandwidth (-3dB)		Hz	ODR/2	ODR/2 Or ODR/8

Temperature Sensor

		KXG03	KXG07/KXG08
Parameter	**Units**		
Operating Temperature Range	°C	-40 – 85	-40 – 85
Output Accuracy	± ºC	1	1
Sensitivity (8-bit digital)	counts/ºC	128	128

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