BMA253/BMA280 TO BMA456MM MIGRATION GUIDE

BMA253/BMA280 TO BMA456MM – Migration guide

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General Description

This document is trying to guide how to migrate from BMA253 or BMA280 to BMA456MM.

BMA253 (12-bit) and BMA280 (14-bit) are not recommended for new design at this moment and will be end of life soon. Customers who use BMA253 or BMA280 need to migrate to BMA456MM (16-bit) accelerometer.

BMA456, the same chip, has three variants. By default, BMA456 is for wearable applications such as smart watch, wristband, etc. If BMA456 is downloaded with another config file, then it becomes BMA456H which is for hearable applications such as headphone, earbud, etc. BMA456H has the triple-tap interrupt feature added.

BMA456MM is a variant of BMA456 with specialized config file that supports most interrupt features of BMA253 and BMA280 for mass market.

BMA456MM (2 x 2 x 0.65mm LGA-12) is pin-to-pin compatible with BMA253 and BMA280 (both 2 x 2 x 0.95mm LGA-12). Let's call BMA253 and BMA280 as BMA2xy in this document.

If BMA2xy was designed in the schematics with SPI interface to an MCU, then BMA456MM can be directly dropped in to replace BMA2xy without the need of PCB redesign. However, if BMA2xy was designed in the schematics with I2C interface to an MCU and the CSB pin-10 of BMA2xy was left floating, then the schematics and PCB layout need to be redesigned to tie this pin to VDDIO.

On software side, BMA456MM and BMA2xy have different register maps and interrupt configuration method. Therefore, some software efforts are required to adopt BMA456MM into system. An example is presented about how to use BMA253 and BMA456MM to implement tilt sensing high-g interrupt in low power mode.

Difference between BMA2xy and BMA456	**Reasonable action**
CSB pin setting for I2C interface (BMA2xy – floating, BMA456 – VDDIO)	Review the schematic and necessary HW changes
Register map is different	It is highly recommended to follow latest BMA456MM API on Github
SPI read action is different (BMA456 needs one dummy byte during SPI read)	
BMA456 needs to load configure string during every power cycle	
The interrupt engine configure method is different	

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1 Spec difference

Please refer to the following table for the parameter difference between BMA253, BMA280 and BMA456MM

Table 1: sensor parameter comparison

General characteristics	**BMA253**	**BMA280**	**BMA456MM**
Package	LGA-12	LGA-12	LGA-12
Size	2mm x 2mm x 0.95mm	2mm x 2mm x 0.95mm	2mm x 2mm x 0.65mm
Resolution	12-bit	14-bit	16-bit
Digital interface	SPI, I2C	SPI, I2C	SPI, I2C
Interrupt output pins	2	2	2
Pin-to-pin compatible	Yes	Yes	Yes
Self-test feature	Yes	Yes	Yes
Bytes of FIFO	192B	192B	1KB
Chip_ID value	0xFA	0xFB	0x16
Available interrupts built-in	DRDY/Any-motion/No-motion/single-tap/double-tap/low-g/high-g/orientation/flat	DRDY/Any-motion/No-motion/single-tap/double-tap/low-g/high-g/orientation/flat	DRDY/Any-motion/No-motion/significant-motion/single-tap/double-tap/triple-tap/low-g/high-g/orientation/auto-wakeup/auto-lowpower
High pass filter built-in	Yes	Yes	No
Step counter built-in	No	No	Yes
Mechanical characteristics			
Measurement Range (FS)	±2g / ±4g / ±8g / ±16g	±2g / ±4g / ±8g / ±16g	±2g / ±4g / ±8g / ±16g
Sensitivity at ±2g FS	1024LSB/g	4096LSB/g	16384LSB/g
Sensitivity Change vs. Temperature	±0.02%/°C	±0.015%/°C	±0.005%/°C
Zero-g offset level	±80mg	±50mg	±20mg
Zero-g Level Change vs. Temperature	±1mg/°C	±1mg/°C	±0.2mg/°C
Output data rate (ODR)	15.62/31.26/62.5/250/500/1000/2000Hz	7.81/15.62/31.26/62.5/250/500/2000Hz	12.5/25/50/100/200/400/800/1600Hz
Output noise density	220ug/√Hz	120ug/√Hz	120ug/√Hz
Operating Temperature Range	-40°C ~ + 85°C	-40°C ~ + 85°C	-40°C ~ +85°C
Electrical characteristics			
Supply voltage VDD	1.62V ~ 3.6V	1.62V ~ 3.6V	1.62V ~ 3.6V
Interface supply voltage VDDIO	1.2V ~ 3.6V	1.2V ~ 3.6V	1.2V ~ 3.6V
Max current consumption at normal mode with maximum ODR	130uA @ max 2000Hz	130uA @ max 2000Hz	150uA @ max 1600Hz
Current consumption at low power mode with 100Hz ODR	14uA	14uA	22uA
Power down mode	1uA	1uA	3.5uA
Turn-on time	3ms	3ms	1ms

2 Hardware migration guide

BMA2xy and BMA456MM have the same package size as mentioned in chapter 1, so the PCB landing pattern for both two sensors are also same. This means the same PCB lib for BMA2xy can be directly used for BMA456MM.

On the schematic level, there are few points need to be considered.

2.1 Pin definition

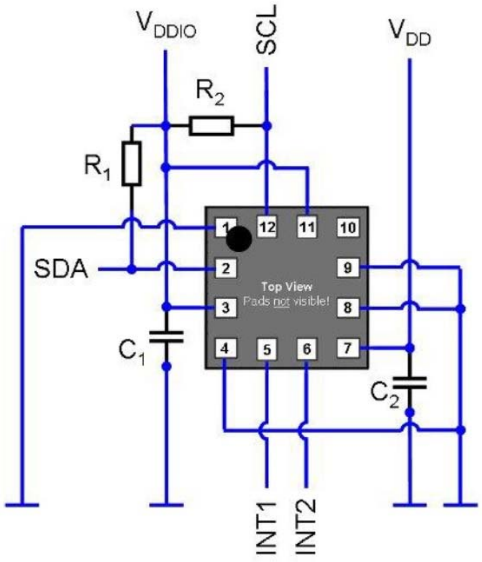

Figure1: pin out of BMA2xy in I2C

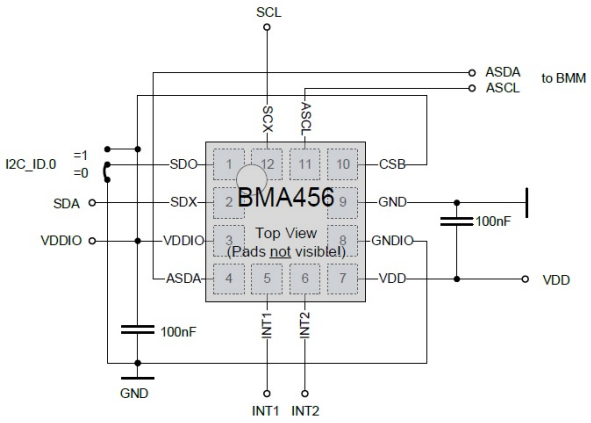

Figure2: pin out of BMA456MM in I2C

Table 2: Pin definition for BMA2xy and BMA456MM

Pin #	Name	BMA2xy			BMA456MM		
		SPI 4W	SPI 3W	I2C	SPI 4W	SPI 3W	I2C
1	SDO	SDO	DNC (float)	GND for default address	SDO	DNC (float)	GND for default address
2	SDX	SDI	SDA	SDA	SDI	SDA	SDA
3	VDDIO	VDDIO	VDDIO	VDDIO	VDDIO	VDDIO	VDDIO
4	NC	GND	GND	GND	VDDIO/GND/Floating/External sensor		
5	INT1	INT1	INT1	INT1	INT1	INT1	INT1
6	INT2	INT2	INT2	INT2	INT2	INT2	INT2
7	VDD	VDD	VDD	VDD	VDD	VDD	VDD
8	GNDIO	GND	GND	GND	GND	GND	GND
9	GND	GND	GND	GND	GND	GND	GND
10	CSB	CSB	CSB	DNC (float)	CSB	CSB	VDDIO
11	PS	GND	GND	VDDIO	VDDIO/GND/Floating/External sensor		
12	SCx	SCK	SCK	SCL	SCK	SCK	SCL

2.2 Hardware migration guide

There is no issue for SPI interface. For I2C interface if BMA2xy pin-10 cannot be tied to VDDIO in existing design, then PCB redesign is needed when migrating to BMA456MM.

BMA2xy has PS (protocol selection) pin-11 to select either I2C or SPI interface. But BMA456MM doesn't have this PS pin. Whenever BMA456MM sees a rising edge signal on CSB pin-10 it will automatically switch from default I2C interface to SPI interface. This means that if that protocol switch happens, then I2C will no longer work because BMA456MM is in SPI interface now. There is a risk for example by random ESD noise the rising edge on CSB pin-10 could happen when this pin is left floating. Power-cycling BMA456MM will bring BMA456MM back to default I2C interface again. That is the reason why BMA456MM CSB pin-10 should be tied to VDDIO for I2C interface rather than being left floating in BMA2xy.

2.3 Differences between BMA2xy and BMA456MM

Power-on-reset: After power up BMA2xy will automatically go to normal mode with 2KHz sampling rate and +/-2g full scale range, while BMA456MM will stay in suspend mode and +/-4g full scale range with I2C interface selected by default. You need to download the config file into BMA456MM. This process is included in BMA456MM API source code "init" function.

Current consumption: BMA2xy has low power mode 1 (LPM1) which automatically switches between normal mode (130uA) and suspend mode (2.1uA) according to the preset sleep time. For example, if the sleep time is set to 25ms, then the total average current consumption will be 6.5uA in low power mode 1 from duty-cycle. If there is an interrupt enabled such as high-g interrupt for example, then the total average current consumption will increase depending on the high-g duration value. This is because BMA2xy needs to stay longer in normal mode for the interrupt duration amount of time to check if the high-g interrupt condition is met or not. If not, then it goes to suspend mode. BMA456MM current consumption in low power mode doesn't depend on any interrupt duration value. It depends on how many samples to average defined by acc_bwp 3 bits in register 0x40, while acc_bwp of 0b000 means single shot with no averaging and acc_bwp of 0b011 for example means averaging 8 samples and then placing final values into data registers.

Digital interface: BMA2xy and BMA456MM have the same I2C read/write and SPI write communication specifications. But for SPI read with one byte or multiple bytes, BMA456MM will give a dummy byte first followed by the real register value(s). BMA456MM API already takes care of this.

Offset compensation: BMA2xy can compensate each axis's offset up to +/-1g, while BMA456MM only +/-0.5g.

High pass filter: BMA2xy has built-in high pass filter with bandwidth of 0.5Hz and 5Hz respectively. BMA456MM doesn't have high pass filter.

FIFO: BMA2xy has 192 bytes FIFO, while BMA456MM 1KB.

Time stamp: BMA2xy doesn't have time stamp, while BMA456MM has 3 bytes of time stamp with 39us/LSB resolution.

3. Software migration guide

To successfully migrate from the BMA2xy to the BMA456MM, the following steps will need to be taken.

3.1 Register map

The register map of the BMA456MM is different from the BMA2xy. It includes command register 0x7E, power control and power config registers 0x7D and 0x7C, feature_IN register 0x5E, and other registers such as step counter, interrupt configuration, data registers, etc. BMA2xy doesn't have all these registers. So it is highly recommended to use BMA456MM API source code to configure BMA456MM.

3.2 Interface operation

For SPI interface, a dummy byte needs to be inserted into read action for BMA456MM. This means if you want to read from BMA456MM, the read back counts will be actual read bytes + 1 always.

For I2C interface, there is no difference for operation between BMA2xy and BMA456MM.

3.3 Configure string load

BMA456MM requires a downloaded config string every time after the sensor is powered on. This is a special requirement of the BMA456MM. Refer to chapter 3 “Quick start guide” of the BMA456 datasheet to review the details of loading the config string.

3.4 Interrupt feature

BMA456MM covers most BMA2xy interrupt features. Considering flat interrupt is not popular in BMA2xy, BMA456MM doesn’t support flat detection interrupt. Instead, BMA456MM added auto-wakeup/auto-lowpower interrupt feature, significant motion interrupt and triple-tap interrupt features that BMA2xy doesn’t have.

To enable the interrupt on BMA456MM, user needs to take a two-step approach. First user must make burst read at the feature engine then enable corresponding interrupt feature and change the parameters. Then the entire interrupt parameter page needs to be written into sensor via burst write. Then user needs to enable the interrupt pin and mapping the interrupt to the corresponding interrupt pin.

The second step is the only step to enable interrupt on BMA456MM.

BMA456MM offers different interrupt features than the BMA2xy as shown in Table 3.

Table 3 Interrupt features comparison

Interrupt features	BMA2xy	BMA456MM	Compatibility
New data (or data ready)	Yes	Yes	Equivalent
Any-motion (Slope)	Yes	Yes	Equivalent
Significant motion	No	Yes	Plus feature
No-motion	Yes	Yes	Equivalent
Orientation (portrait / landscape)	Yes	Yes	Equivalent
Flat detection	Yes	No	Not supported
High-g (impact or shock)	Yes	Yes	Equivalent
Low-g (freefall)	Yes	Yes	Equivalent
Tap sensing	Single/double	Single/double/triple	Plus feature
Auto-wakeup/auto-lowpower	No	Yes	Plus feature
FIFO full/watermark	Yes	Yes	Equivalent

3.5 SW migration guide

To get a smooth software migration from BMA2xy, the API of BMA456MM is highly recommended to use directly in customer project.

The BMA456MM API can be download from Github. For the best software migration from the BMA2xy, Bosch recommends use of the BMA456MM API available on Github.

The following screenshot is the API structure of BMA456MM. There are some sample codes in the “examples” folder to show how to use API to read sensor data or implement some interrupt features.

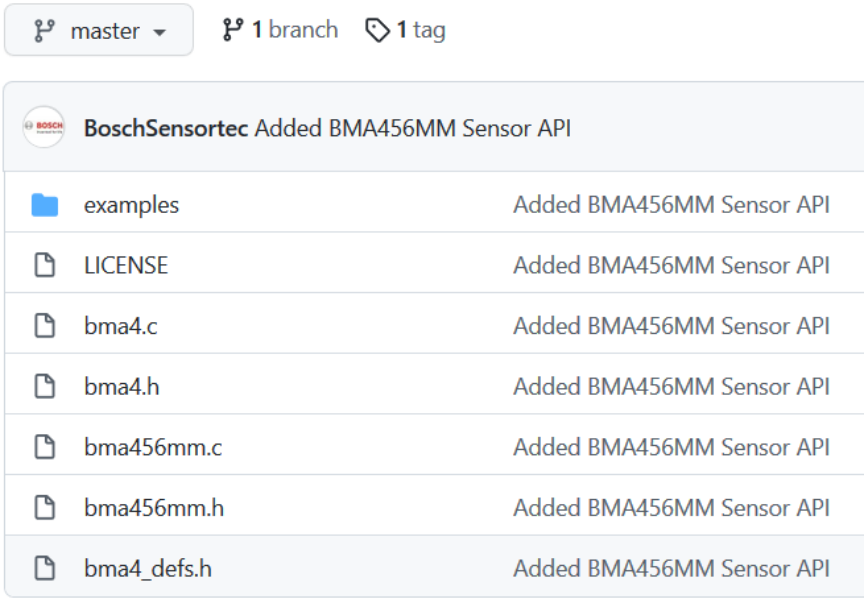

Figure 3 BMA456MM API structure

BMA456MM has specialized config file that supports most interrupt features of BMA2xy.

- BMA456MM app note about the feature set is available online at https://www.bosch-sensortec.com/media/boschsensortec/downloads/application_notes_1/bst-bma456-an001-01.pdf
- BMA456MM API source code is available online at https://github.com/BoschSensortec/BMA456MM-Sensor-API

If you want to evaluate BMA456MM, then with the above shuttle board you also need to,

- Purchase application base board 3.0 at https://www.bosch-sensortec.com/software-tools/tools/application-board-3-0/

Download Development Desk 2.0 SW or COINES SW at https://www.bosch-sensortec.com/products/downloads/#software

4. Legal disclaimer

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4.3 Application examples and hints

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5. Document history and modifications

Rev. No	Chapter	Description of modification/changes	Date
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