Data Synchronization for BMI08x IMUs
Application Note

Application Note – Data Synchronization for BMI085 & BMI088

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Notes	Data and descriptions in this document are subject to change without notice. Product photos and pictures are for illustration purposes only and may differ from the real product appearance

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1. Introduction

BMI08x family is a system-in-package inertial measurement unit which offers accurate acceleration and angular rate measurements. Due to system-in-package approach (two sensors in single package), the gyroscope and acceleration data is acquired in a non-synchronized manner. However, the synchronization between accelerometer and gyroscope can be easily achieved. This document describes how synchronization between accelerometer and gyroscope can be achieved in a typical application such as augmented or virtual reality.

To achieve data synchronization on BMI08x, the data ready interrupt signal from the gyroscope of the BMI08x needs to be connected to one of the interrupt pins of the BMI08x accelerometer (which can be configured as input pins). The internal signal processing unit of the accelerometer uses the data ready signal from the gyroscope to synchronize and interpolate the data of the accelerometer, considering the group delay of the sensors. The accelerometer part can then notify the host of available data. With this technique, it is possible to achieve synchronized data and provide accelerometer data up to ODR of 2 kHz. The data synchronization feature supports 400 Hz, 1000 Hz and 2 kHz data rates.

1.1. Concept

The data synchronization feature supports for both BMI085 & BMI088 sensors. Synchronized data means that the acquisition of the gyroscope and accelerometer data is happening at the same time and the signals have same propagation time. The time between motion to register read-out depends on the physical propagation time mainly caused by signal processing path and analog-to-digital conversion and is sensor specific. The typical group delay of the gyroscope and accelerometer signals is disclosed in the tables below.

Accelerometer output data rate (Hz)	BMI085 group delay (ms)	BMI088 group delay (ms)
1600	typ. 0.625	typ. 1.1
800	typ. 1.25	typ. 1.8
400	typ. 2.5	typ. 3

Gyroscope output data rate (Hz)	BMI085 & BMI088 group delay (ms)
2000	typ. 1.5
1000	typ. 2.5
400	typ. 7

The synchronization between accelerometer and gyroscope data to a common point of time and a common group delay can be realized with the help of the internal processing unit of the accelerometer. The internal processing unit of accelerometer part measures the timestamp of the accelerometer analog-to-digital conversion data ready signal and the timestamp of the gyroscope data ready signal. Finally, the processing unit interpolates the acceleration data by using the timestamp difference, the known group delay of every signal path, stores the synchronized data in the general purpose register and sets the interrupt data ready pin to high. The synchronized sensor data can be read from accelerometer and

gyroscope data registers by the host. The refresh rate of the registers is linked to gyroscope data rate (400 Hz, 1 kHz, 2 kHz).

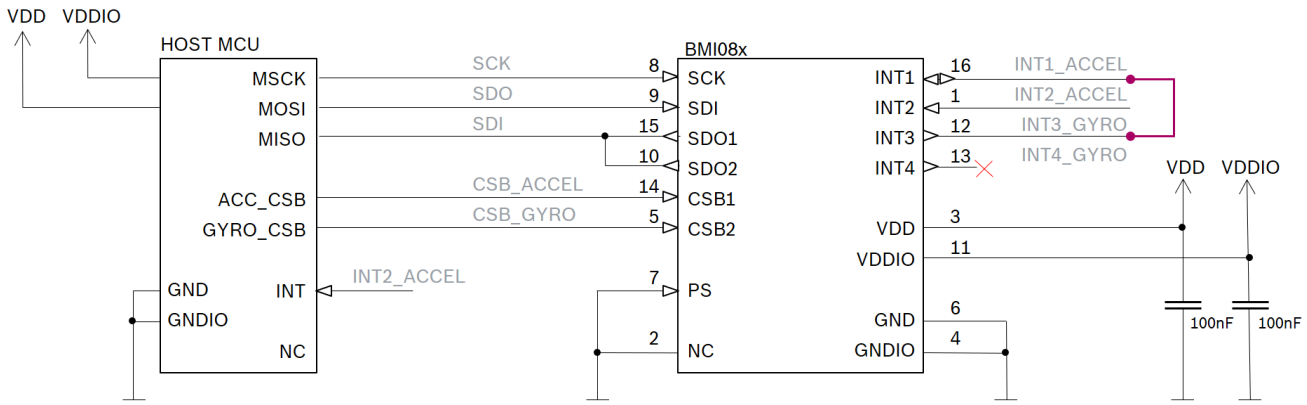
The hardware interrupts pins (INT1 / INT3) of the BMI08x are used for data synchronization purposes. The interrupt pin INT2 can be used for data ready notification to the host by BMI08x.

2. Technical Realization

The data synchronization feature requires physical interrupt pin's connection of the sensors on the pcb and a special configuration of the BMI08x. Requirements and the steps are described below.

2.1. Application schematic

The typical application circuit diagram by using BMI08x synchronized data output is shown in the figure below. The interrupt pin INT1 and INT3 of BMI085 must be to be connected externally on pcb. For host notification, pin (INT2) shall be used. For latency-critical multisensory applications, it is recommended to use SPI interface for fastest sensor data read (recommended SPI clock speed is >2MHz). Additionally, it is recommended to use edge triggered interrupt configuration on the host mcu.



2.2. Software

In order to use the data synchronization feature of BMI08x, several sensors configuration steps are required and shall be applied after every power on reset (POR) or soft reset. Besides the sensor configuration, it is furthermore required to load binary code into the processing unit of the accelerometer part. It is highly recommended to use the Bosch Sensortec BMI08x sensor API (https://github.com/BoschSensortec/BMI08x-Sensor-API).

2.3. Sensor Initialization

The sensor API also contains a readme file (DataSync.md), were the user can find the API calls that need to be executed in order to set up the synchronization feature. It is highly recommended also to consider the delays, which are sometimes needed between the executions of the different API calls.

2.4. **Read synchronized sensor data**

As soon as the host will be notified by BMI08x data ready interrupt (INT2), the synchronized IMU data can be read from data registers. The angular rate data can be read from data registers (*0x02 – 0x07*) of the gyroscope part, while the synchronized acceleration data can be found in the general purpose data registers (*0x1E and 0x27*) of accelerometer part. In addition to the synchronized data, the raw acceleration data and if required the sensor time can be read from the appropriate registers.

The acceleration data are stored in following data registers of accelerometer part:

1) Raw sensor data at *0x12* (length = 6 bytes: *ax, ay, az*)
2) Synchronized accelerometer data ax, ay at *0x1E* (length = 4 bytes: *ax_sync, ay_sync*)
3) Synchronized accelerometer data az at *0x27* (length = 2 bytes: *az_sync*)
4) Sensor time can be read out at *0x18* (length = 3 bytes)

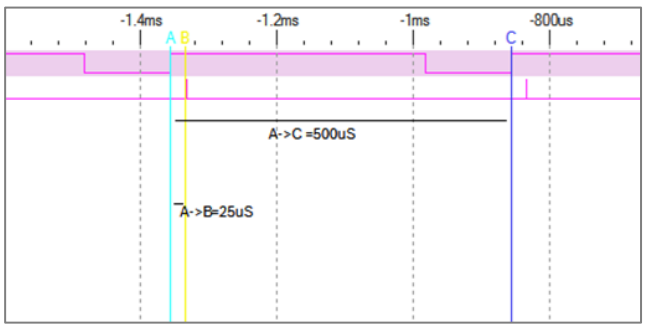
2.5. **Sample code**

A piece of sample code showing the required steps to be undertaken in order to receive synchronized data can be found as part of the COINES tool on Bosch Sensortec's web page: https://www.bosch-sensortec.com/software-tools/tools/coines/

3. **Synchronization Feature Timings**

Parameter	Time	Notes
Gyroscope sampling time	typ. 500us	
Accelerometer internal sampling time	typ. 625us	
Accelerometer synchronized data sampling time	typ. 500us	synchronized to gyroscope data ready interrupt
Accelerometer data ready latency	typ. 25us	latency between gyroscope data ready interrupt and accelerometer data ready interrupt
Synchronization accuracy	typ. <100us	
Latency / group delay of synchronized data (motion-to-data ready)	typ. 1.5ms @ 2kHz ODR typ. 2.5ms @ 1kHz ODR typ. 7ms @ 400Hz ODR	

Snapshot of logic analyzer, showing the gyro data ready signal (marker A, C) and the time delay until the accelerometer's internal signal processor as processed the data and sends a data ready signal to the host (marker B).



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5. Document History and Modification

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Bosch Sensortec GmbH
Gerhard-Kindler-Straße 9
72770 Reutlingen / Germany

contact@bosch-sensortec.com
www.bosch-sensortec.com

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