CE223468 – PSoC 6 MCU: Interfacing BMI160 (I2C) in FreeRTOS

Objective

This code example demonstrates how to interface PSoC® 6 MCU with a BMI160 Motion Sensor over an I^2C interface within a FreeRTOS task. This example reads raw motion data and estimates the orientation of the board.

Requirements

Tool: ModusToolbox™ IDE 1.1

Programming Language: C

Associated Parts: All PSoC 6 MCU parts

Related Hardware: PSoC 6 BLE Pioneer Kit, E-ink Display Shield Board CY8CKIT-028-EPD

Overview

This code example includes I^2C interface configuration for BMI160 Motion Sensor, FreeRTOS configuration on Arm® Cortex®-M4 CPU, and FreeRTOS task implementation for a BMI160 sensor interface over I^2C. The motion task configures the I^2C interrupt callback where the task resume/wakeup is handled. The task wakes up on the motion sensor interrupt, gets data from BMI160 (suspends the task while the I^2C hardware retrieves the data), converts the data to indicate the orientation of the sensor, and then displays the spatial orientation information on a terminal application using the UART interface.

Hardware Setup

This example uses the kit's default configuration. Refer to the kit guide to ensure the kit is configured correctly.

Plug in the E-INK display shield on to the Pioneer board as Figure 1 shows.

Figure 1. Hardware Setup

Note: The PSoC 6 BLE Pioneer kit and the PSoC 6 WiFi-BT Pioneer kit ship with KitProg2 installed. ModusToolbox works only with KitProg3. Before using this code example, make sure that the kit is upgraded to KitProg3. See **ModusToolbox Help** > **ModusToolbox IDE Documentation** > **User Guide**, section *PSoC 6 MCU KitProg Firmware Loader*. If you do not upgrade, you will see an error such as "unable to find CMSIS-DAP device" or "KitProg firmware is out of date".

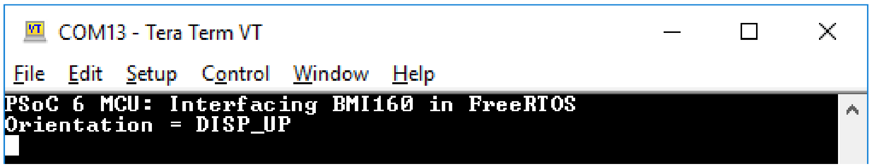
Software Setup

This example uses a terminal emulator. Install one if you don't have one. The instructions use Tera Term.

Operation

1. Connect the kit to your PC using the provided USB cable.
2. Open your terminal software and select the KitProg COM port, with a baud rate setting of 115200 bps. Set the other serial port parameters to 8N1.
3. Add the code example to the IDE, in a new workspace. See KBA225201.
4. Program the PSoC 6 MCU device. In the project explorer, select the **CE223468_BMI160_FreeRTOS_mainapp** project. In the Quick Panel, scroll to the **Launches** section and click **Program (KitProg3)**.
5. Confirm that the terminal application displays the code example title and the initial orientation, as Figure 2 shows.

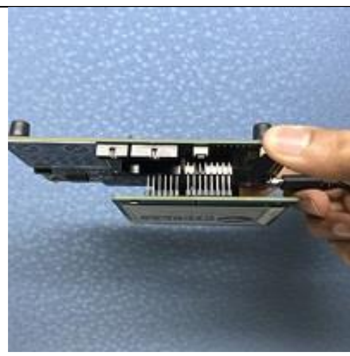
Figure 2. Terminal Application Displaying Startup Message



Note: If the terminal displays an error message, check the connection of the motion sensor or E-INK Display shield with the Pioneer base board.

6. The accelerometer sensor data is used to estimate the board's spatial orientation. The terminal application display shows one of the six orientation states as shown in Table 1.

Table 1. Orientation States

 Orientation = DISP_UP	 Orientation = DISP_DOWN	 Orientation = RIGHT_EDGE
 Orientation = TOP_EDGE	 Orientation = BOTTOM_EDGE	 Orientation = LEFT_EDGE

Debugging

You can debug the example to step through the code. Click **Debug (KitProg3)**. See KBA224621 to learn how to start a debug session with ModusToolbox IDE.

Design and Implementation

The E-INK Display Shield (CY8CKIT-028-EPD) contains a BMI160 motion sensor (U5), which is a low-power inertial measurement unit (IMU) providing 3-axis acceleration and 3-axis gyroscopic measurements. PSoC 6 MCU interfaces with this sensor and reads the motion data, which is converted into orientation data, and displayed on the terminal application.

The BMI160 motion sensor is interfaced with PSoC 6 MCU using an I^2C interface and two interrupt pins. BMI160 has a hardware-selectable I^2C slave address, depending on the logic driven on the SDO pin. On the E-INK Display Shield, the SDO pin is pulled to GND, which selects the slave address 0b1101000 (0x68).

BMI160 provides two output pins (INT1 and INT2) to which various interrupt events can be assigned. In this example, the orientation interrupt is assigned to INT2. INT1 is not used this application. On the E-INK Display Shield, INT1 and INT2 pins are connected to pin 2 and 1 of J3 respectively. On the Pioneer Baseboard, INT1 and INT2 connects to P13[1] and P13[0] of PSoC 6 MCU. See the BMI160 datasheet for more details on interrupt outputs.

The INT2 output is configured to provide a rising-edge signal with a pulse width of 2.5 ms. On PSoC 6 MCU, P13[0] is configured as an input pin and is internally pulled down. The interrupt is used to detect changes in the orientation. Raw accelerometer data is read and processed on the orientation interrupt to compute the orientation.

An SCB-based resource in I^2C mode is used to implement the I^2C master interface to BMI160. The I^2C data rate is set to 400 kbps. Configuring of the motion sensor and reading accelerometer information are performed over this interface. This example configures the I^2C interrupt callback where the task resume/wakeup is handled.

Table 2 lists the tasks used in this application:

Table 2. RTOS task used in the application

Task	Purpose
Task_Motion	This task unblocks on an interrupt from BMI160 sensor. The task initiates an I^2C transfer to read the sensor data. This task is suspended after initiating an I^2C transfer and resumes the task after the transfer is complete. The sensor data is processed to determine the board's orientation.
Task_Debug	This task provides thread-safe debug message printing. The main loop waits until a message to be printed has been received over the queue.

Resources and Settings

Table 3 lists some of the PSoC 6 MCU device resources used in the example, and how they are used in the design. The *design.modus* file contains all the configuration settings. For example, for pin usage and configuration, open the **Pins** tab of the design file.

Table 3. ModusToolbox Resources

Resource	Alias	Purpose	Non-default settings
SCB3	KIT_I2C	I^2C master for communicating with the motion sensor	See Figure 3.
SCB5	KIT_UART	Prints messages on terminal program	See Figure 4.
Digital Output Pin	KIT_UART_TX	Used for UART transmit (Tx)	This is autoconfigured when SCB5 is configured.
Digital Input Pin	KIT_UART_RX	Used for UART receive (Rx)	
	Orient_INT	Used for receiving interrupt from BMI160 sensor	See Figure 5.
Digital In Out Pin	KIT_I2C_SCL	Used for I^2C serial clock	This is autoconfigured when SCB3 is configured.
	KIT_I2C_SDA	Used for I^2C serial data	

Figure 3 to Figure 5 highlight the non-default settings for each resource in this example.

Figure 3. I^{2}C Configuration

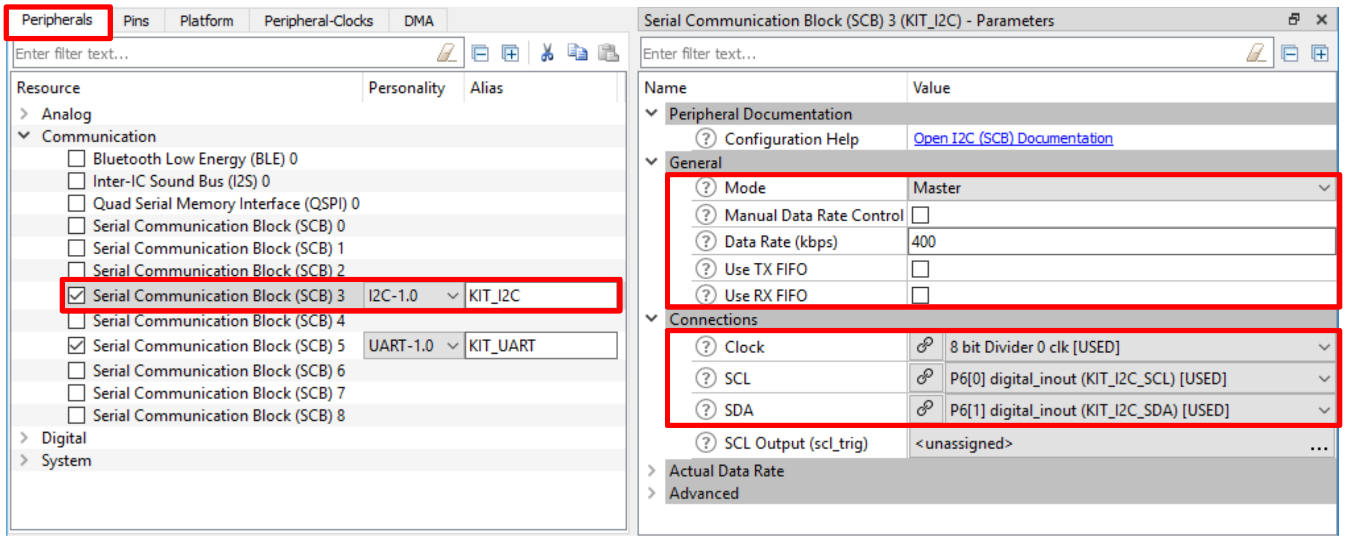


Figure 4. UART Configuration

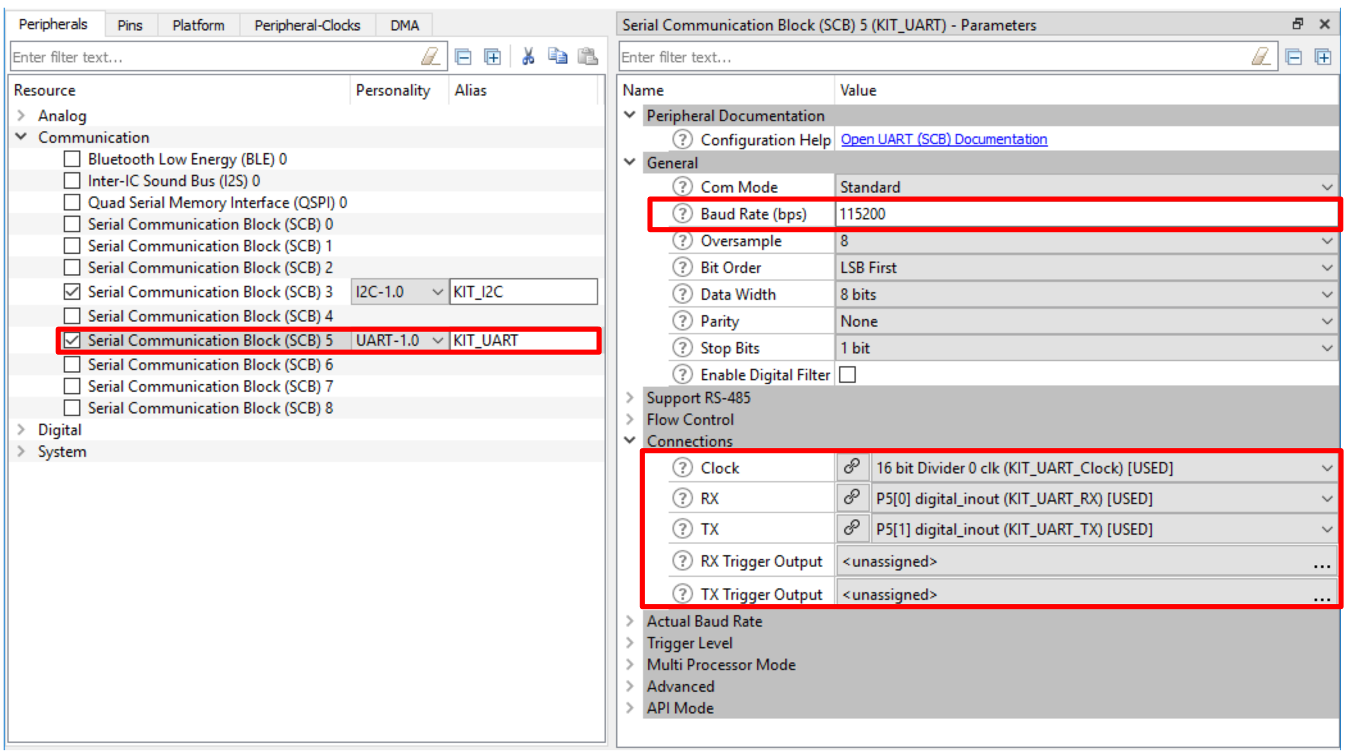
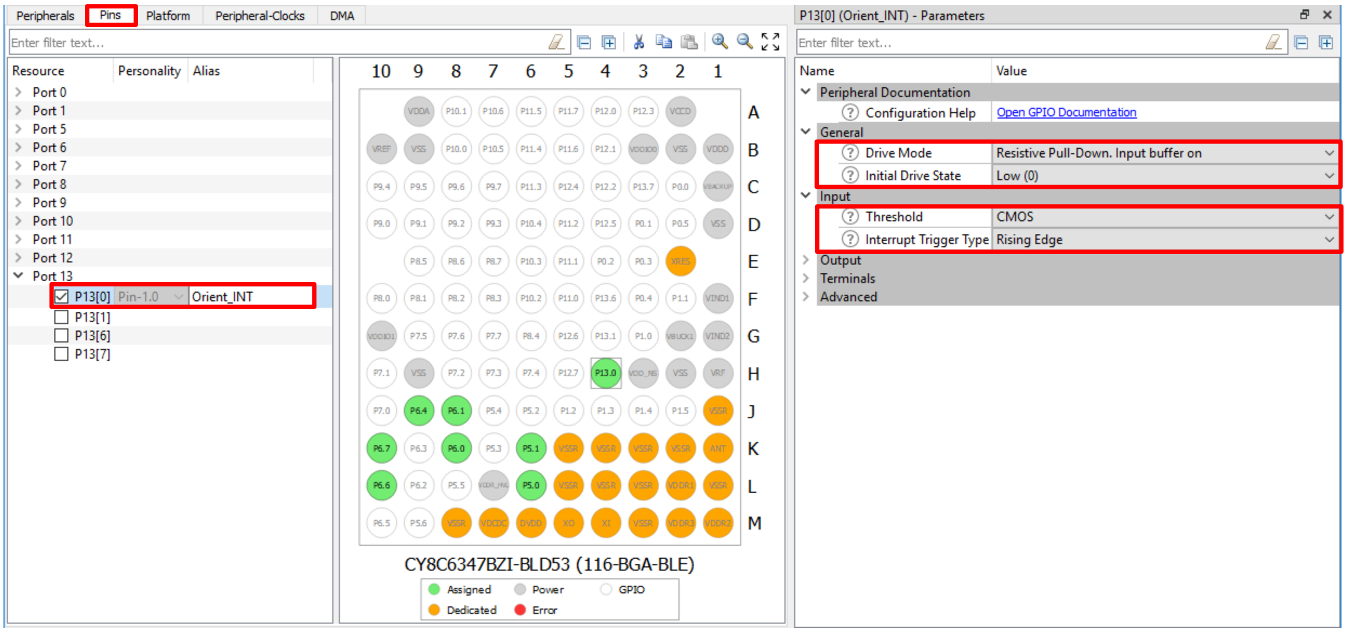


Figure 5. GPIO Pin Configuration for BMI160 Interrupt Pin



Reusing This Example

This example is configured for the supported kit(s). To port the design to a different PSoC 6 MCU device, right-click the application project and choose **Change Device**. If changing to a different kit, you may need to reassign pins.

Table 4. Device and Pin Mapping across PSoC 6 MCU Kits

Kit Name	Device Used	UART_RX	UART_TX	KIT_I2C_SCL	KIT_I2C_SDA	Orient_INT
CY8CKIT-062-WiFi-BT	CY8C6247BZI-D54	P5[0]	P5[1]	P6[0]	P6[1]	P13[0]
CY8CKIT-062-BLE	CY8C6347BZI-BLD53	P5[0]	P5[1]	P6[0]	P6[1]	P13[0]

In some cases, a resource used by a code example (for example, an IP block) is not supported on another device. In that case, the example will not work. If you build the code targeted at such a device, you will get errors. See the device datasheet for information on which resources a device supports.

Related Documents

Application Notes	
AN210781 – Getting Started with PSoC 6 MCU with Bluetooth Low Energy (BLE) Connectivity	Describes PSoC 6 MCU with BLE Connectivity devices and how to build your first PSoC Creator project
AN221774 – Getting Started with PSoC 6 MCU	Describes PSoC 6 MCU devices and how to build your first PSoC Creator project and ModusToolbox application
AN215656 – PSoC 6 MCU: Dual-CPU System Design	Describes the dual-CPU architecture in PSoC 6 MCU, and shows how to build a simple dual-CPU design
Code Examples	
Visit the Cypress GitHub site for a comprehensive collection of code examples using ModusToolbox IDE	
Device Documentation	
PSoC 6 MCU: PSoC 63 with BLE Datasheet	PSoC 6 MCU: PSoC 63 with BLE Architecture Technical Reference Manual
Development Kits	
CY8CKIT-062-BLE PSoC 6 BLE Pioneer Kit	
CY8CKIT-062-WiFi-BT PSoC 6 WiFi-BT Pioneer Kit	
CY8CPROTO-062-4343W PSoC 6 Wi-Fi BT Prototyping Kit	
CY8CPROTO-063 BLE PSoC 6 BLE Prototyping Kit	
Tool Documentation	
ModusToolbox IDE	ModusToolbox simplifies development for IoT designers. It delivers easy-to-use tools and a familiar microcontroller (MCU) integrated development environment (IDE) for Windows, macOS, and Linux.

Cypress Resources

Cypress provides a wealth of data at www.cypress.com to help you to select the right device, and quickly and effectively integrate the device into your design.

For the PSoC 6 MCU devices, see KBA223067 in the Cypress community for a comprehensive list of PSoC 6 MCU resources.

Document History

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Revision	ECN	Orig. of Change	Submission Date	Description of Change
**	6482004	AJYA	02/14/2019	New code example

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