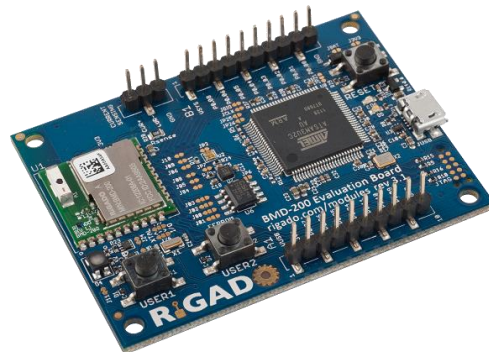


BMD-200 Evaluation Kit User Guide

This document describes the **BMD-200** Evaluation Kit from Rigado. This Evaluation Kit allows for stand-alone use of the **BMD-200** module featuring the Nordic nRF51822 RF System on Chip (SoC).

The purpose of this guide to provide setup instructions for starting development and to describe the hardware functionality of the **BMD-200** Evaluation Kit.



1. Overview

The BMD-200 Evaluation Kit is a versatile hardware platform that provides an easy jumping off point for almost any Bluetooth 4.1 Low Energy project. The kit can be powered externally via USB or with a CR2032 coin cell battery for portable use. USB provides a programming and debug interface (J-Link or CMSIS-DAP), as well as communication via a virtual COM port. Two user configurable buttons are available, as well as an RGB LED, ambient light sensor, accelerometer, EEPROM, and a current sense resistor. There is also an on-board reset button. Breakout headers allow easy access to all of the BMD-200 GPIO pins.

1.1. Key Features

- ⚙ BMD-200 Bluetooth 4.1 System on Module (SoM)
- ⚙ On-board programming and debug (J-Link or Drag-&-Drop/CMSIS-DAP)
- ⚙ Virtual COM port over USB
- ⚙ Full GPIO pin out of BMD-200
- ⚙ I2C 3-axis accelerometer ([NXP MMA8652FC](#))
- ⚙ Ambient light sensor ([Avago APDS-9005-020](#))
- ⚙ 16kb SPI EEPROM ([ON Semi CAT25160VI-GT3](#))
- ⚙ Buttons and LEDs for user interaction
- ⚙ 32.768kHz Crystal
- ⚙ CR2032 battery holder

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1.2. Useful Tools

Below is a list of tools that aid in development with the BMD-200 Bluetooth module. Not all tools will be required depending on which software suite is used.

<i>Tool</i>	<i>Description</i>
Nordic nRFgo Studio	The Nordic software suite is used to program and configure Nordic nRF devices. It supports programming of nRF51 application, bootloader, and soft device. This tool uses the on board SEGGER J-Link programming interface.
nRF Master Control Panel for Android	A Nordic tool for Android devices to allow active scanning for Bluetooth low energy devices and communication.
Keil MDK-ARM Development Kit	A development environment designed for microcontroller applications that enables development using the nRF51 SDK application and example files.
SEGGER J-Link Software	Software and documentation pack for the SEGGER J-Link interface
mbed Windows serial port driver	Windows serial port driver for mbed version of Evaluation Board.

2. Hardware Kit

The two different BMD-200 Evaluation kits contains each of the following:

BMD-200-EVAL-S

- 1x BMD-200 Evaluation Board with on-board Segger JLink programmer
- 1x Micro-USB to USB-A cable

BMD-200-EVAL-M

- 1x BMD-200 Evaluation Board with on-board CMSIS-DAP(mbed) programmer
- 1x Micro-USB to USB-A cable

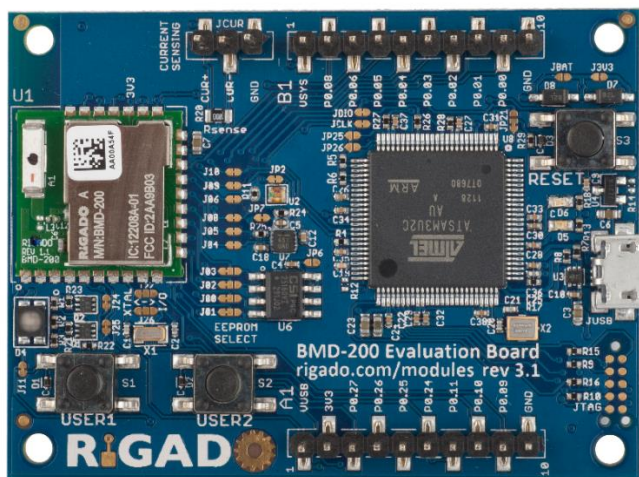


Figure 1 – BMD-200 Evaluation Board (Top View)

3. Getting Started

This section walks through how to set up and program the BMD-200 Evaluation Kit.

3.1. Evaluation Board with SEGGER J-Link

The BMD-200-Eval-S comes with a built in SEGGER J-Link programmer/debugger on board.

3.1.1. Set up tool chain

1. Download and install the latest Keil MDK-ARM development kit from www.keil.com/arm/mdk.asp
 - a. Once the Keil MDK-ARM installation is complete, Keil will launch the Pack Installer. The Keil Pack Installer manages software components for the various supported microcontrollers.
 - b. The Pack Installer will automatically download any updates for the core ARM support.
 - c. Once these core packs are installed and up to date, close the Pack Installer
Note: *As of Nordic Semiconductor SDK v11.0.0, Keil Packs are not supported. The full SDK with the currently released SoftDevices is installed with step 4 below.*
2. Download and install the nRFgo Studio from www.nordicsemi.com/eng/Products/2.4GHz-RF/nRFgo-Studio
3. Download and install the latest Segger J-Link utilities from <https://www.segger.com/jlink-software.html>. When prompted to overwrite the JLinkARM.dll file, select all of the listed items and click OK:

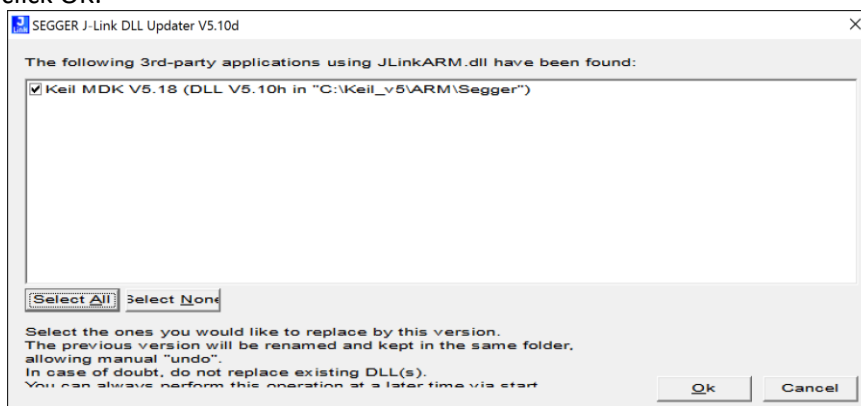


Figure 2 – Segger J-Link DLL Updater

4. Download the latest Nordic Semiconductor nRF5 SDK from http://developer.nordicsemi.com/nRF5_SDK/nRF5_SDK_v11.x.x. Extract the Zip file to a working folder.
5. Download the BMD-200 Eval Kit Board Support File, custom_board.h, at <https://www.rigado.com/product/bmd-200-eval-kit/>. Save the file to the following directory: <unzipped SDK location>\examples\bsp\.

3.1.2. Connect BMD-200 Evaluation Kit to computer

1. Connect the BMD-200 Evaluation Board to a computer using the USB cable provided
2. The status LED, D6, will turn on indicating the board has power
3. After a few seconds the computer will recognize the Evaluation Board as a J-Link device

3.1.3. Program BMD-200 Evaluation Kit with the S130 Soft Device

1. Open the Nordic nRFgo Studio application. In the 'Device Manager' window, there will be a device named Segger followed by serial number under 'nRF51 development boards.' Select Segger and the device programming interface will appear in the main window
2. Click 'Erase all' to clear the device of all current programmed software
3. Select the 'Program SoftDevice' tab in the pane on the right
4. Click 'Browse...' and navigate to the location of the extracted SoftDevice (<unzipped SDK location>\components\softdevice\s130\hex. Select the SoftDevice hex file
5. Click program
6. After programming, nRFgo Studio should look similar to Figure 4.

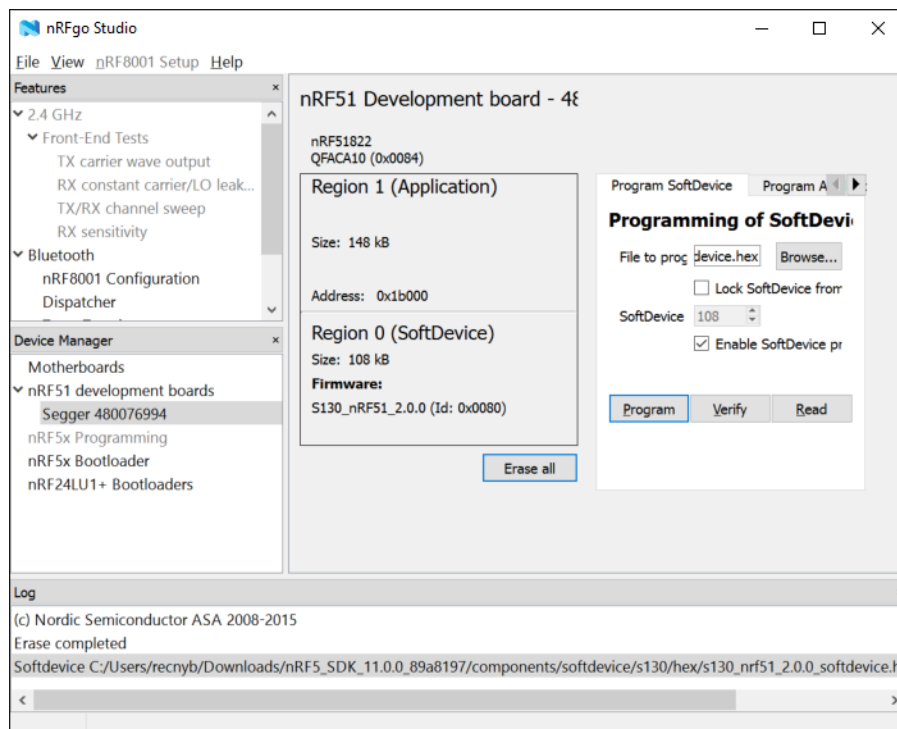


Figure 3 – nRFgo Studio SoftDevice Window

7. Note the starting address of Region 1 for the application firmware (0x1B000 in this example)
8. Close nRFgo Studio.

Note: The S110 SoftDevice may be more suitable for the BMD-200-A with 16KB RAM

3.1.4. Set up the Application Project

1. Navigate to the location of the extracted examples from the SDK (typically <unzipped location>\nRF5_SDK_11.0.0_89a8197\examples).
2. Select one of the examples that is labeled with “(nRF51 PCA10028)” and “s130”. The Heart Rate Service Sample Application ((<unzipped SDK location>\ble_peripheral\ble_app_hrs\pca10028\s130\arm5_no_packs\) is a good place to start. For starting on a custom application, using a template project is a good idea (such as ble_app_template_s130_pca10028).

Note: If the S130 SoftDevice was selected in the previous section, select an example that is also labeled for use with S130.

Likewise, if the S110 SoftDevice was selected in the previous section, select an example that is also labeled for use with S110.

3. Open the project file (ble_app_hrs_s130_pca10028.uvprojx) to start the Keil IDE.
4. In the ‘Project’ drop down menu click on ‘Options for Target ‘nrf51422_xxac_s130’’. In this window go to the ‘Target’ tab make sure that the settings for the IROM starting address matches the value from nRFgo Studio. Leave the other values at their default settings.

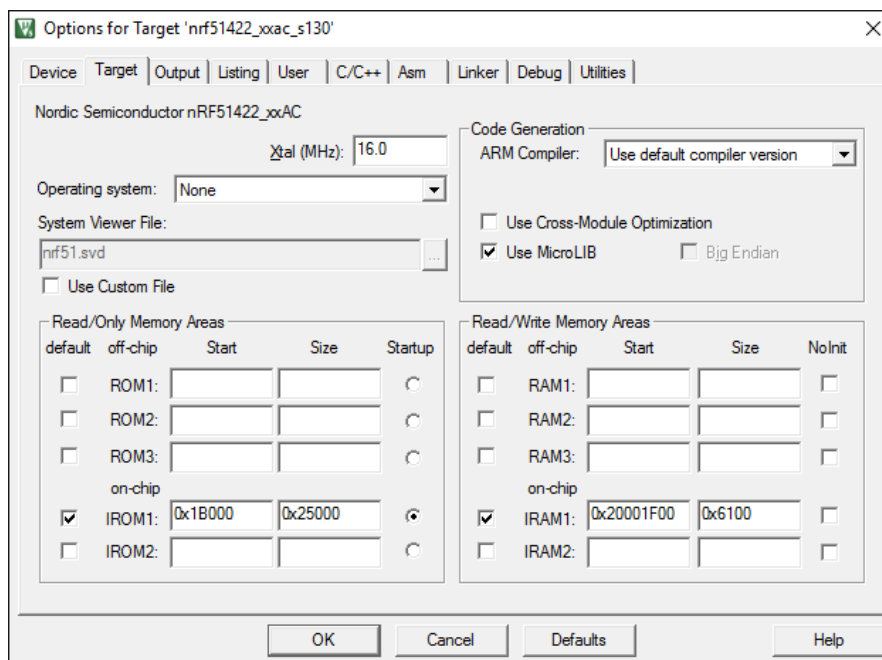


Figure 4 – Keil Flash Tools Target Window

Note: The memory locations in Figure 4 are based on the size of the S130 SoftDevice v2.0.0. If a different SoftDevice is used, these values may need to be adjusted. The SoftDevice specification documents contain the ROM and RAM requirements of each SoftDevice, see Nordic’s website.

- Go to the 'C/C++' tab, and in the field marked 'Define' change "BOARD_PCA10028" to "BOARD_CUSTOM" as shown in Figure 6.

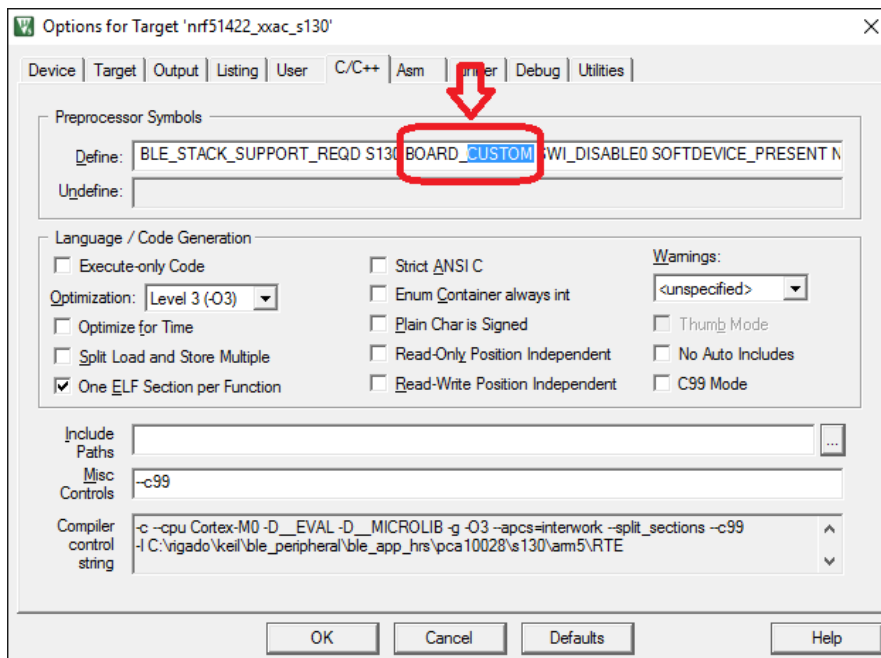


Figure 5 – Keil Flash Tools C/C++ Window

- In the 'Debug' tab of the same 'Options for Target' window, select 'J-LINK/J-TRACE Cortex' from the upper right hand drop down menu then click 'Settings.' The same 9 digit serial number from the nRFgo program should be in the 'SN' field to acknowledge Keil sees the Evaluation Board (see figures 7 and 8).

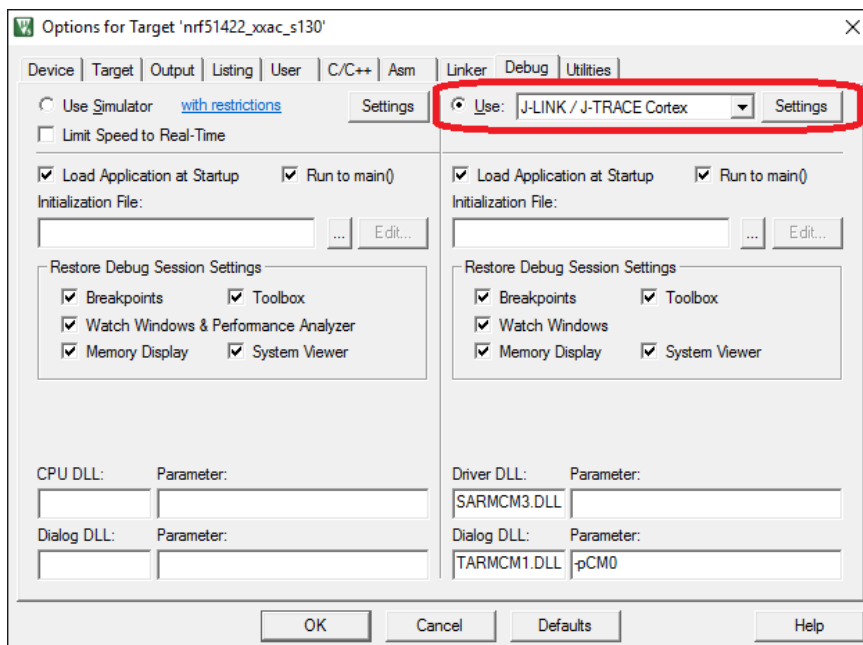


Figure 6 – Keil Flash Tools Debug Window

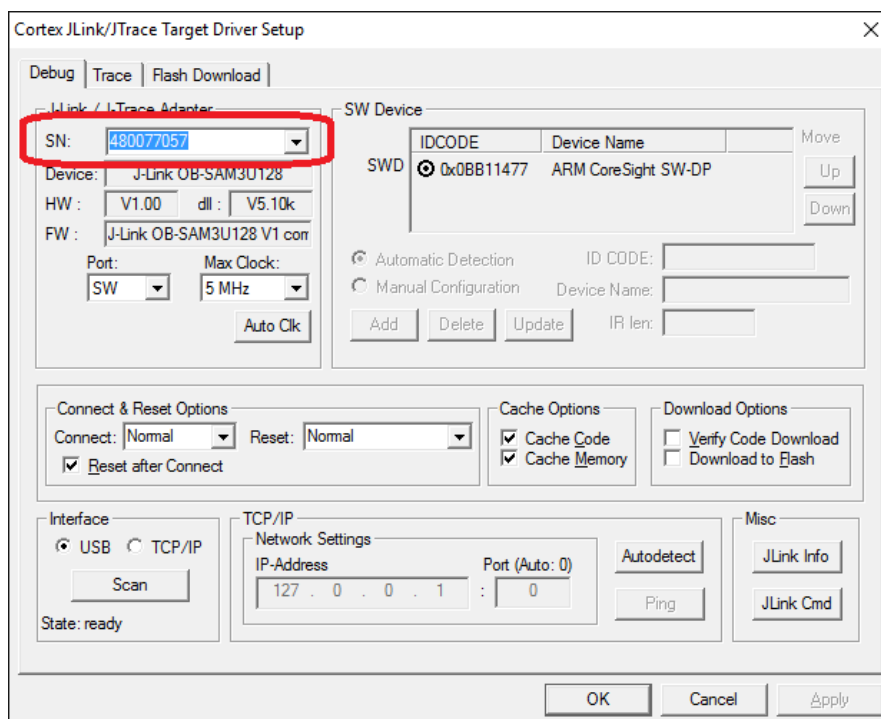




Figure 7 – Keil Flash Tools Debug Settings Window

7. Build (, 'F7') and download the example program to the Evaluation Board (, 'Flash' -> 'Download').
8. Your BMD-200 Evaluation Board should now be running the example application.
9. If the Heart Rate Service example was loaded in step2 and 3, its functionality may be checked with the "nRF Toolbox" app on iOS or Android. Run the app and select the heart rate monitor (HRM). Make the connection to the "Nordic_HRM" device.

3.2. Evaluation Board with CMSIS-DAP (mbed)

The BMD-200-Eval-M comes with a built in CMSIS-DAP (mbed) programmer on board.

3.2.1. Connect BMD-200 Evaluation Kit to computer

1. Connect the BMD-200 Evaluation Board to a computer using the USB cable provided
2. The status LED, D6, will turn on indicating the board has power
3. After a few seconds the computer will recognize the board as a standard USB drive named 'MBED'

3.2.2. Program BMD-200 Evaluation Kit (Drag and Drop)

1. Register for an mbed account at developer.mbed.org.
2. Go to <http://developer.mbed.org/platforms/Nordic-nRF51822/> and add the Nordic nRF51822 platform to your compiler.
3. Import either the [blinky app for the BMD-200](#) or the [mbed library modified for the BMD-200](#) (replaces the "mbed" library).
4. Click 'Compile' along the top toolbar in the mbed compiler page. When complete it will automatically download hex file.
5. Drag and drop the downloaded hex file into the 'MBED' drive. This will automatically program the Evaluation Board. The status LED, D6, will flash while programming.

6. The program will automatically run when programming is complete. If an error occurs, a file called 'fail.txt' will be created on the 'MBED' drive giving the reason for the failure.

Note: *Keil and other design environments can program and debug the Evaluation Board using the on-board CMSIS-DAP compatible programmer.*

Note: *The BMD-200 can be fully erased by holding down 'Reset' button for 5 seconds. After 5 seconds, status LED, D6, will flash faster while erasing. Once the erase procedure is complete, status LED, D6, will return to solid, and communication LED, D5, will turn off.*

4.1. Power

The BMD-200 Evaluation Board has two possible power sources: the Micro-USB header and the coin cell battery. These power sources are isolated from each other by default to allow both to be connected simultaneously.

The USB +5V supplies the 3.3V LDO regulator, and the 3.3V connects to VSYS through a diode OR with VBATT. VSYS is required for operating the BMD-200 and sensors on the Evaluation Board. The 5V rail provides power for the programming interface only, and is only required when programming or debugging. There are several options for configuring the power rails. Jumper J7 and J6 allow the user to select the power source for the 5V and 3V rails. If running the Evaluation Board from the battery for long periods of time, short the solder jumper, JBAT, together to bypass the diode and gain extra battery life. If JBAT is shorted, the battery MUST be removed before connecting to USB power or it will damage the battery.

4.2. Buttons

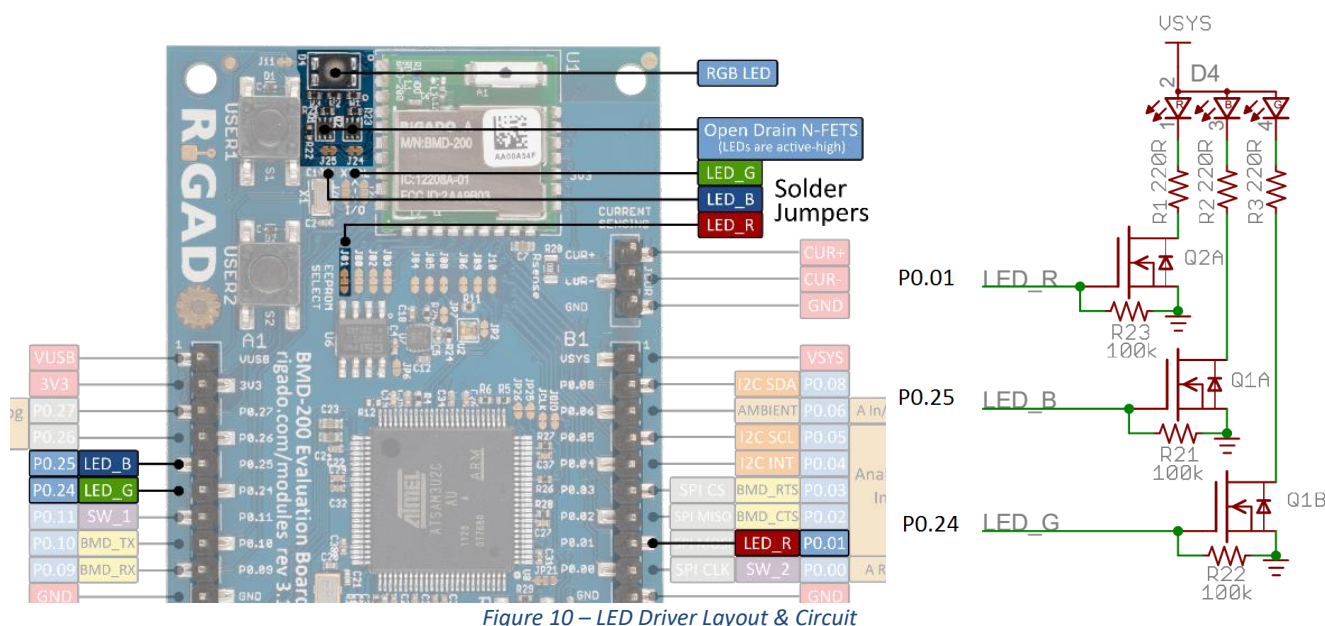
The Evaluation Board has three switches: Reset, User 1, and User 2. All buttons are active low; they will connect to ground when pressed.

The Reset button has different behaviors based on the version of Evaluation Kit. On the BMD-200-EVAL-S it is a true hard reset to the BMD-200; do not press this during programming/debugging as it may cause the device to become unrecoverable. On the BMD-200-EVAL-M, the Reset button has three purposes. If held while powering on the Evaluation Board, it will enter the mbed bootloader mode for updating the mbed programmer. During normal operation the BMD-200-EVAL-M Reset button will perform a reset to the BMD-200 if powered through USB, but if powered from the battery the Reset button has no function. A long press (5 seconds) of the Reset button will perform a full erase of the BMD-200.

User Button 1 is connected to pin 23/P0.11, and User Button 2 is connected to pin 11/P0.00. The nRF51822 pins should be configured with pull-up resistors for proper operation when using the user buttons. The pins are also routed to the breakout headers.

4.3. LEDs

One user controllable RGB LED is provided on the Evaluation Board. The LED contains a red, green, and blue LED in a single package with a common anode that is connected to VSYS. Each cathode is connected to a separate GPIO pin on the BMD-200 through an N-FET. The N-FET inverts the logic so the LED enable signals are active high. The red LED is connected to pin 12/P0.01, the green LED is connected to pin 5/P0.24, and the blue LED is connected to pin 6/P0.25. The red and blue LEDs are also routed to the breakout headers.



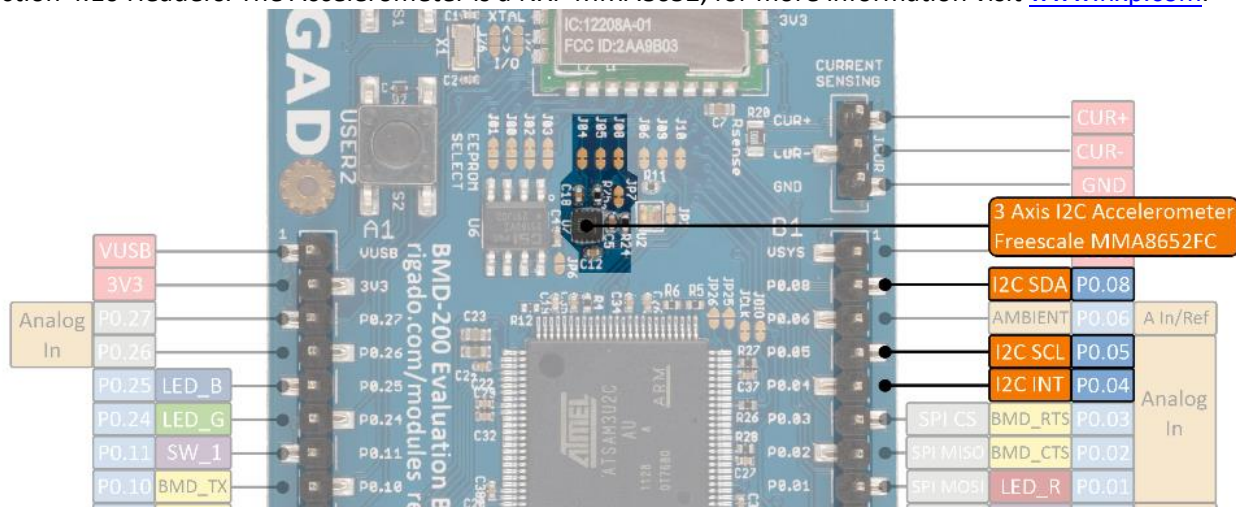
4.4. Virtual COM Port

A virtual COM port over USB is provided to communicate with the BMD-200. The VCOM_TX UART signal is connected to pin 21/P0.09, and the VCOM_RX UART signal is connected to pin 22/P0.10. The nRF51288 should configure this UART to TX on P0.10 and RX on P0.09. There are also flow control pins for the UART; VCOM_CTS is connected to pin 14/P0.03, VCOM_RTS is connected to pin 13/P0.02. The nRF51288 should configure this UART to RTS on P0.03 and CTS on P0.02. Flow control is always enabled for the BMD-200-EVAL-S.

Communication LED, D5, will turn on during virtual COM port activity.

4.5. Accelerometer

The BMD-200 Evaluation Board comes with an on board 3-Axis Accelerometer that communicates over I2C. There is one programmable interrupt request line from the accelerometer to allow for interrupt flags on events, such as: tap-detect, motion, free-fall, and FIFO-threshold. For pin connection to BMD-200 see section 4.10 Headers. The Accelerometer is a NXP MMA8652, for more information visit www.nxp.com.



4.6. SPI EEPROM

The BMD-200 Evaluation Board has one 16kb SPI EEPROM. It is not connected to the BMD-200 by default; to enable the interface the solder bridge must be reconfigured, see section 4.11 GPIO Jumpers. The EEPROM is a CAT25160VI-GT3 from On Semiconductor, for more information visit www.onsemi.com.

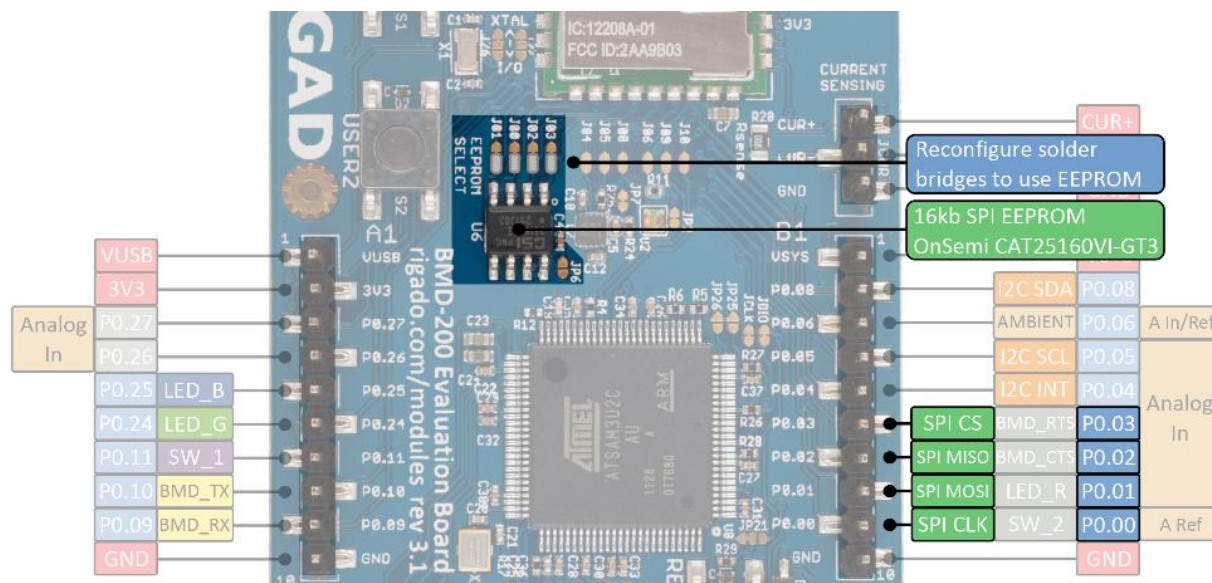


Figure 12 – LED Driver Layout

4.7. Ambient Light Sensor

The on-board Ambient Light Sensor is a current output sensor. Load resistor R11 (4.75kΩ) to convert the current output into a voltage for measurement by the BMD-200 ADC on pin P0.06. The light sensitivity range is set to have a linear response across most light conditions. The output range of the sensor is 0V to ~2.1V. Configuring the BMD-200 ADC to use the internal band-gap reference with input prescaling set to 2/3 will enable measurement for most of the usable light range with the greatest resolution. The Ambient Light Sensor is an APDS-9005 from Avago, for more information visit www.avagotech.com.

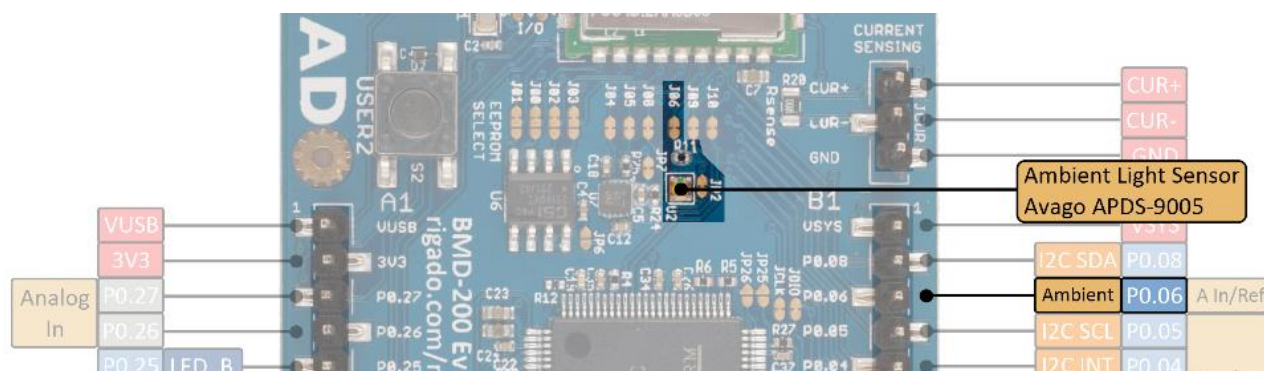


Figure 13 – Ambient Light Sensor Layout

4.8. 32kHz Crystal Oscillator

The BMD-200 Evaluation Board has a 32.768kHz Crystal Oscillator connected to the BMD-200 by default. This external oscillator is not required for operation, as an internal Ring Oscillator is also available. To disconnect crystal oscillator, see section 4.11 GPIO Jumpers.

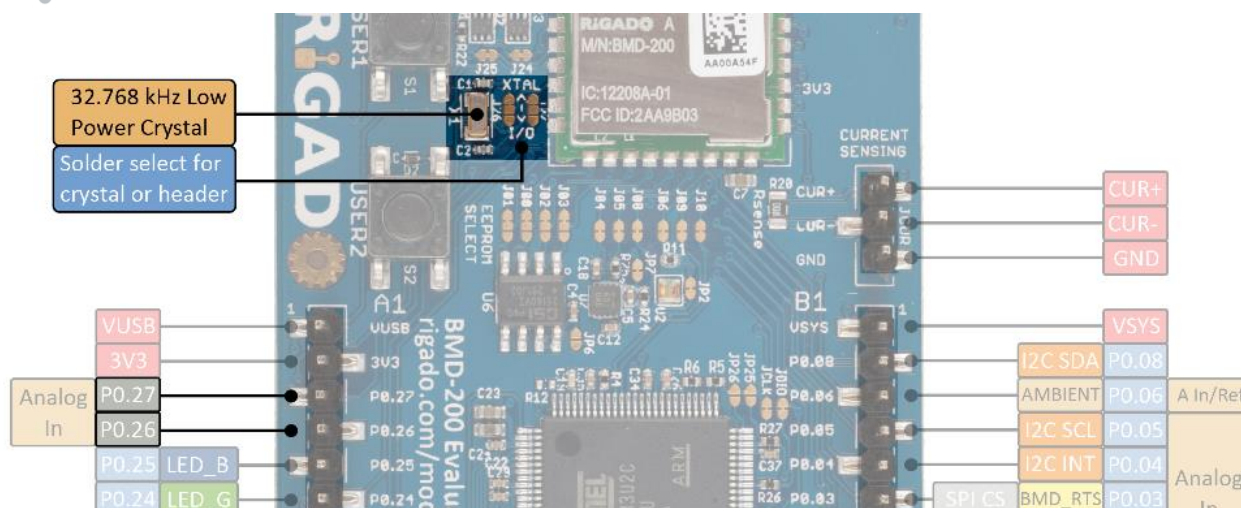


Figure 14 – 32KHz Crystal Oscillator Layout

4.9. Current Sensing Header

The current sensing header, JCUR, allows for power consumption measurement of the BMD-200. The three pin, .1" pitch header has two pins connected across a 1 ohm current sense resistor powering the BMD-200, and the third pin to ground. To measure current consumption use a multimeter or other precision voltage measurement device to measure voltage drop across pins one and two. Measuring the current directly can also be accomplished by removing R20 and using a current meter in series with pins one and two. The default hardware configuration does not require any modification of the current sense header for the BMD-200 Evaluation Board to perform properly.

Note: Only current into the BMD-200 VCC pin flows through R20. Current sunk into GPIO pins and peripheral power usage is not accounted for.

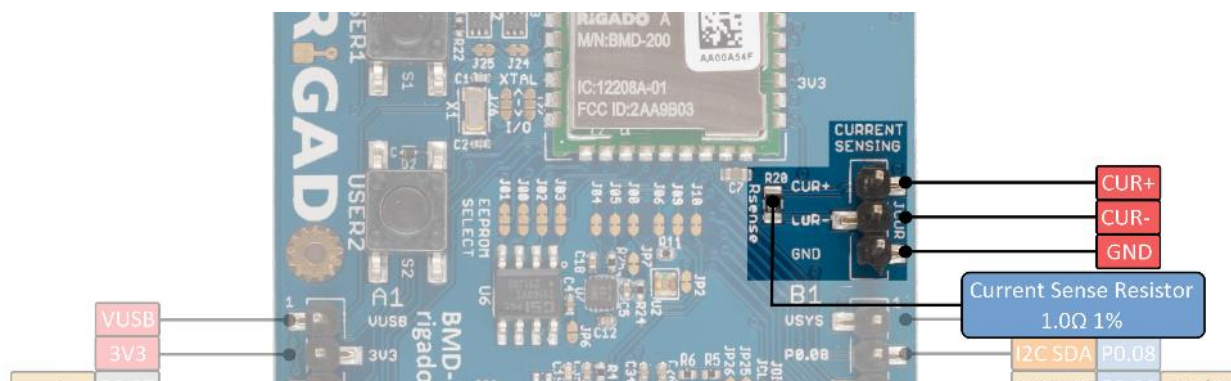


Figure 15 – Current Sensing Header Layout

4.10. Headers

The connectors `A1` and `B1` break out the IO signals from the BMD-200 to two 0.1" pitch ten pin headers. To use a pin's alternate functions listed below, see section 4.11 GPIO Jumpers.

Connector A1					
Header Pin	Pin Name	BMD-200 Pin	nRF51 Port	Default Function	Alternate Function
1	VUSB	-	-	+5.0V USB Power	
2	VSYS	-	-	+3.3V System Power	
3	P0.27	9	P0.27	32kHz Oscillator P2	GPIO
4	P0.26	11	P0.26	32kHz Oscillator P1	GPIO
5	P0.25	6	P0.25	Blue LED ~PWM	
6	P0.24	5	P0.24	Green LED ~PWM	
7	P0.11	23	P0.11	User Switch 1	
8	P0.10	22	P0.10	UART VCOM RX	
9	P0.09	21	P0.09	UART VCOM TX	
10	GND	-	-	System Ground	

Connector B1					
Header Pin	Pin Name	BMD-200 Pin	nRF51 Port	Default Function	Alternate Function
1	VSYS	-	-	+3.3V System Power	
2	P0.08	20	P0.08	Accel I2C SDA	
3	P0.06	17	P0.06	Ambient light ADC	
4	P0.05	16	P0.05	Accel I2C SCL	
5	P0.04	15	P0.04	Accel Interrupt 1	
6	P0.03	14	P0.03	UART VCOM RTS	EEPROM SPI ~CS
7	P0.02	13	P0.02	UART VCOM CTS	EEPROM SPI MISO
8	P0.01	12	P0.01	Red LED ~PWM	EEPROM SPI MOSI
9	P0.00	11	P0.00	User Switch 2	EEPROM SPI CLK
10	GND	-	-	System Ground	

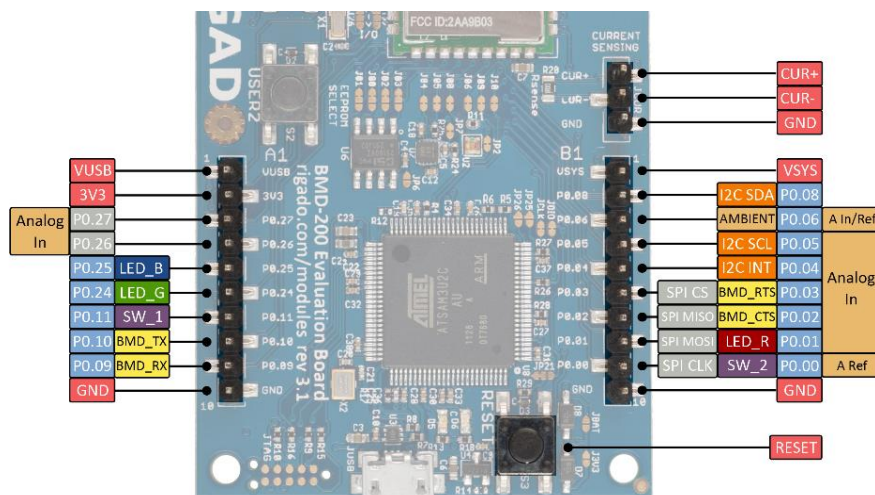


Figure 16 – Header Layout

5. Schematic

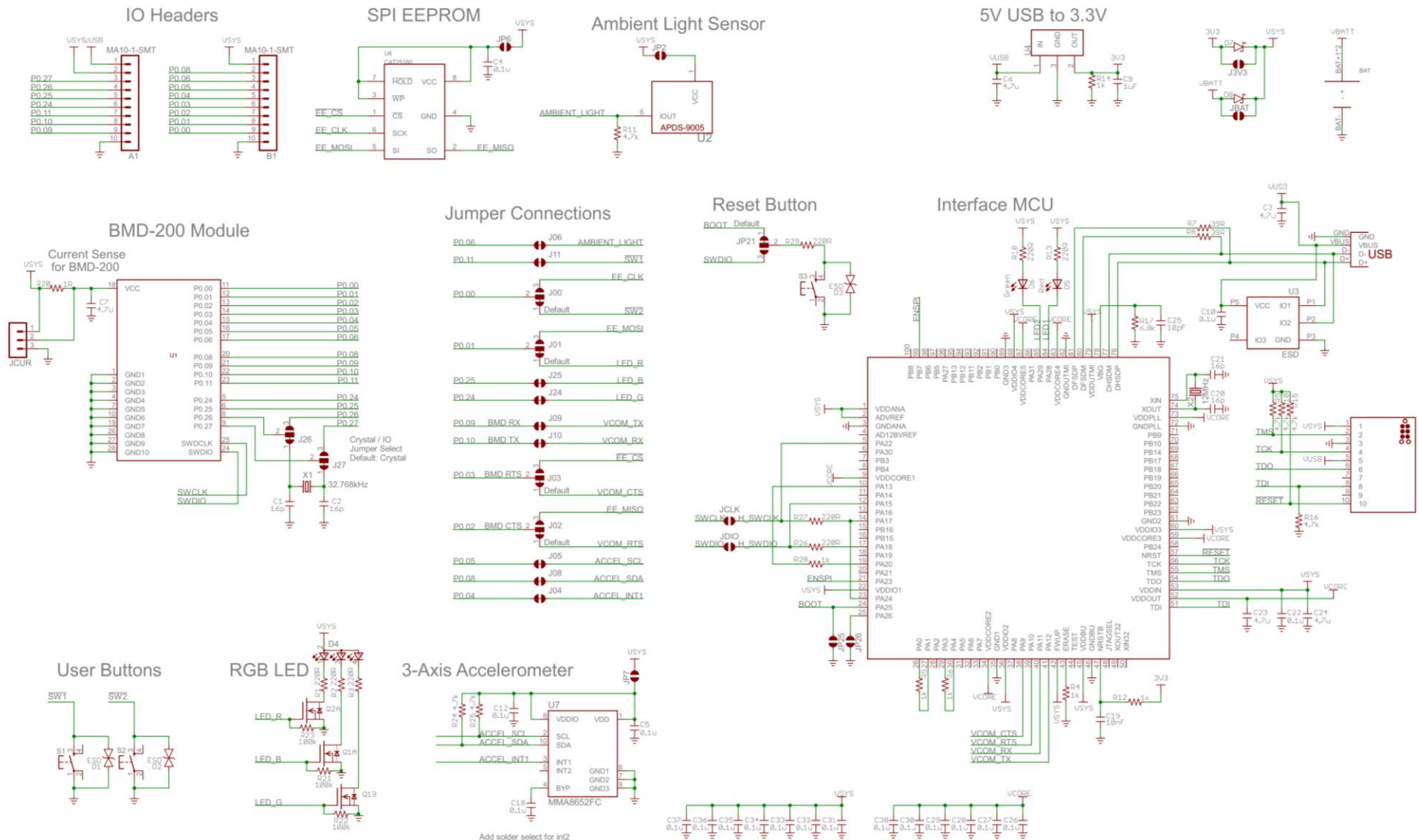


Figure 18 – BMD-200 Evaluation Board Schematic

6. BMD-200 Pinout

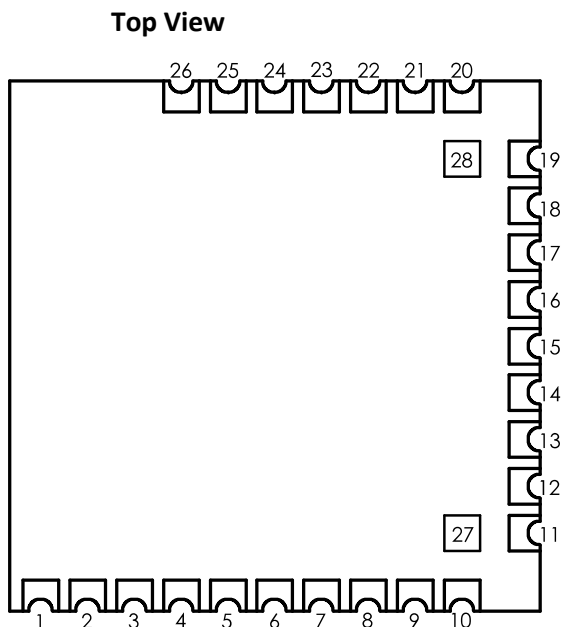


Figure 19 – BMD-200 Pin-out

Pin description			
Name	Pin	Direction	Description
P0.24	5	In/Out	GPIO
P0.25	6	In/Out	GPIO
P0.26	8	In/Out	GPIO/AIN1/XTAL2 (32.768kHz)
P0.27	9	In/Out	GPIO/AIN0/XTAL1(32.768kHz)
P0.00	11	In/Out	GPIO/AREF0
P0.01	12	In/Out	GPIO/AIN2
P0.02	13	In/Out	GPIO/AIN3
P0.03	14	In/Out	GPIO/AIN4
P0.04	15	In/Out	GPIO/AIN5
P0.05	16	In/Out	GPIO/AIN6
P0.06	17	In/Out	GPIO/AIN7/AREF1
P0.08	20	In/Out	GPIO
P0.09	21	In/Out	GPIO
P0.10	22	In/Out	GPIO
P0.11	23	In/Out	GPIO
SWDIO	24	In/Out	SWD IO/ $\overline{\text{RESET}}$
SWCLK	25	In	SW Clock ¹
VCC	18	Power	+2.1 to +3.6VDC input ²
GND	1, 2, 3, 4, 7, 10, 19, 26, (27, 28 opt.)	Power	Electrical Ground

Note 1: SWDCLK has an internal 12 k Ω pull-down resistor.

Note 2: An external capacitor for V_{CC} is not strictly required, however using a 1 μ F - 4.7 μ F ceramic capacitor is recommended.

7. Life Support Policy

This product is not designed to be used in a life support device or system, or in applications where there is potential for a failure or malfunction to, directly or indirectly, cause significant injury. By using this product in an application that poses these risks, such as described above, the customer is agreeing to indemnify Rigado for any damages that result.

8. Document History

Revision	Date	Changes / Notes
0.1	12/26/14	Initial document draft
1.0	1/13/15	Initial release
1.1	2/5/15	Updated for formatting, clarity
1.2	5/29/15	Updated for nRF51 SDK v8.1
1.3	3/22/16	Updated to show use of S130, updated to reflect changes in Nordic SDK
1.4	8/10/16	Updated logo and address on first page

9. Related Documents

Rigado Documents:

- ⚙ BMD-200-DS: Module Datasheet
- ⚙ BMD-200-AN-1: MAC Address Provisioning

Nordic Semiconductor Documents:

- ⚙ nRF51822-PS: nRF51822 Product Specification
- ⚙ nRF51 RM: nRF51 Series Reference Manual
- ⚙ S110-SDS: nRF51822 S110 SoftDevice Specification
- ⚙ S120-SDS: nRF51822 S120 SoftDevice Specification
- ⚙ S130-SDS: nRF51822 S130 SoftDevice Specification