RIGADO

BMD-3xx-EVAL User Guide

1 Contents

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2   Introduction

The BMD-3xx-EVAL kits from Rigado allow for stand-alone use of the BMD-300, BMD-301, and BMD-350 modules featuring the Nordic nRF52832 RF System on Chip (SoC), the BMD-330 module featuring the Nordic nRF52810 RF SoC and BMD-360 module featuring the Nordic nRF52811 RF SoC. Other Rigado modules have evaluation kits covered by other documents.

These Evaluation Kits provide a great starting point for almost any Bluetooth 5 Low Energy project. All features of the BMD-3xx are easily accessed from the evaluation board. A simple USB connection provides power, programming, and a virtual COM port. Four user buttons are available, as well as four LEDs and a reset button. All 32 GPIO are available on headers that are compatible with the Arduino form factor. This allows easy use of any existing Arduino shields. Current sense resistors allow for measuring current into the BMD-3xx module and into the shield.

This guide provides setup instructions for starting development and describes the hardware functionality of the BMD-3xx-EVAL boards.

2.1   Key Features

- BMD-300 Series Module
- On-board programming and debug (Segger J-Link-OB)
- Able to program external modules
- Virtual COM port over USB

- Full GPIO of the module
- Buttons and LEDs for user interaction
- NFC antenna connector
- 32.768kHz Crystal
- CR2032 battery holder

3   Hardware Kit
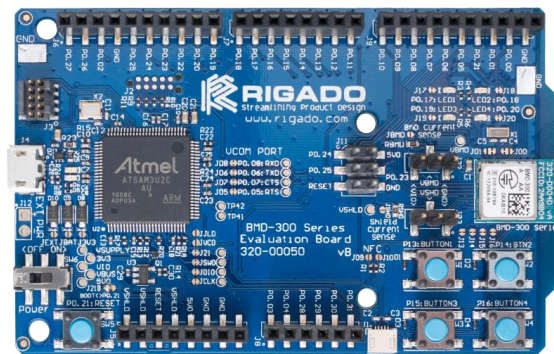
Figure 1 – BMD-300 Evaluation Board (Top View)

BMD-300-EVAL:

- BMD-300 Evaluation Board
- Micro-USB Cable
- NFC antenna

BMD-350-EVAL:

- BMD-350 Evaluation Board
- Micro-USB Cable
- NFC Antenna

BMD-330-EVAL or BMD-360-EVAL:

- BMD-330 Evaluation Board
- Micro-USB Cable

BMD-301-EVAL:

- BMD-301 Evaluation Board
- Micro-USB cable
- NFC Antenna
- Patch antenna
- Tilt-whip antenna
- U.FL to RP-SMA jumper cable

4   Development Tools

The tools listed below will aid in development with the BMD-300 Series Bluetooth modules. Not all tools will be required depending on which software suite is used.

Tool	Description
Segger Embedded Studio	Segger Embedded Studio is an easy-to-use integrated development environment with project management tools, editor and debugger supporting ARM Cortex devices. Full debug support including Real Time Terminal (RTT) output is also available. Available for Windows, macOS, and Linux. Free license for use with the Nordic nRF5 ICs and modules: http://license.segger.com/Nordic.cgi
Segger J-Link Software and Documentation Pack	J-Link Commander (JLink.exe) is a command line-based utility that can be used for verifying proper functionality of J-Link as well as for simple analysis of the target system. It supports some simple commands, such as memory dump, halt, step, go etc. to verify the target connection. Available for Windows, macOS, and Linux.
Nordic Semiconductor SDK	The nRF5 SDK is your first stop for building fully featured, reliable and secure applications with the nRF52 and nRF51 Series. It offers developers a wealth of varied modules and examples right across the spectrum including numerous Bluetooth Low Energy profiles, Device Firmware Upgrade (DFU), GATT serializer and driver support for all peripherals on all nRF5 Series devices. SDKs for Bluetooth Mesh, Thread, Zigbee and other protocols are also available.
Nordic Semiconductor nRF Connect for Desktop	nRF Connect is a cross-platform tool that enables testing and development with Bluetooth® Low Energy (previously called Bluetooth Smart). It allows easy setup of connections with other devices and uses these connections to read and write the external nodes. Available for Windows, macOS, and Linux.
Nordic Semiconductor nRF Connect for Mobile	nRF Connect for Mobile, previously known as nRF Master Control Panel, is a powerful generic tool that allows you to scan and explore your Bluetooth Low Energy devices and communicate with them. nRF Connect for Mobile supports several Bluetooth SIG adopted profiles, as well as the Device Firmware Update profile (DFU) from Nordic Semiconductor or Eddystone from Google. Available for iOS and Android.
Nordic Semiconductor Mobile Apps	Additional mobile utilities for your application development. Available for iOS and Android.

Table 1 – Useful Tools

5 Application Firmware Development

This section walks through how to set up and program the BMD-300 Series Evaluation Kit with an example application.

5.1 Set up the tool chain

1) Install Segger Embedded Studio and request a license.

2) Download the latest nRF5 SDK. Unzip it to a convenient working directory. Be sure *not* to alter the directory trees. The examples are configured for relative path positions.

3) Install nRF Connect on desktop PC and optionally one of the mobile versions. nRF Connect can be used directly with the Device Under Test (DUT) Eval board for programming and other features.
If using nRF Connect on a desktop, a second Eval board or a nRF52 USB Dongle will be needed to make BLE connections with your DUT.

4) Install the Segger J-Link Commander. If presented with a screen to select different IDEs, ensure at least the "SEGGER Embedded Studio ARM" line is selected:
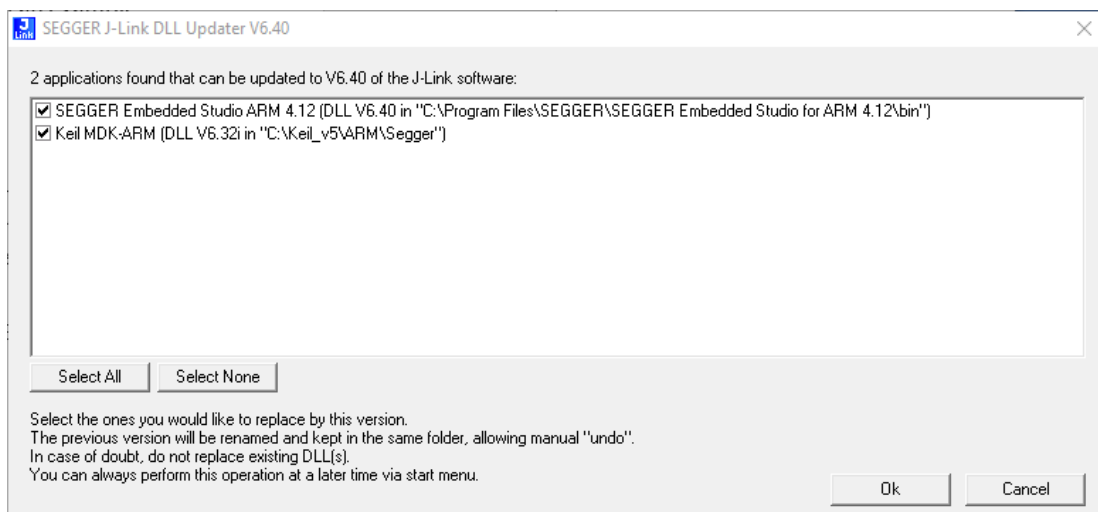

Figure 2 – SEGGER J-Link Commander Install

5) You may need to add the install location to the system PATH. The default location for the J-Link Commander is: `C:\Program Files (x86)\SEGGER\JLink_Vnnn`

… where "nnn" is the version number.

6) Install nRF Toolbox for your mobile device. This will be used with the example below.

5.2 Connect BMD-3xx-EVAL to computer

The evaluation board is provided with an on-board Segger J-Link programmer/debugger.

1. Connect the board to a computer using the USB cable provided.
2. The status LED, D5, will flash and then turn solid once the USB device is enumerated.

3. After a few seconds the computer will recognize the Evaluation Board as a J-Link device and install the USB-Virtual COM Port device driver.
4. Run the J-Link Commander:
    a. `JLink` on Windows
    b. `JLinkExe` on macOS and Linux
5. Type "`connect`" at the `J-Link>` prompt
6. Enter the device type at the `Device>` prompt
    a. Type `nRF52832_XXAA` for the BMD-300, BMD-301, or BMD-350
    b. Type `nRF52810_XXAA` for the BMD-330
7. Enter `S` to select the SWD interface and accept the default for the speed.
8. J-Link will respond with several items. Here is a sample output:


```
C:\Program Files (x86)\SEGGER\JLink_V640>JLink
SEGGER J-Link Commander V6.40 (Compiled Oct 26 2018 15:06:29)
DLL version V6.40, compiled Oct 26 2018 15:06:02

Connecting to J-Link via USB...O.K.
Firmware: J-Link OB-SAM3U128-V2-NordicSemi compiled Jul 12 2018
11:44:41
Hardware version: V1.00
S/N: 682582391
VTref=3.300V


Type "connect" to establish a target connection, '?' for help
J-Link>connect
Please specify device / core. <Default>: NRF52832_XXAA
Type '?' for selection dialog
Device>NRF52832_XXAA
Please specify target interface:
  J) JTAG (Default)
  S) SWD
  T) cJTAG
TIF>S
Specify target interface speed [kHz]. <Default>: 4000 kHz
Speed>
Device "NRF52832_XXAA" selected.


Connecting to target via SWD
Found SW-DP with ID 0x2BA01477
Found SW-DP with ID 0x2BA01477
Scanning AP map to find all available APs
AP[2]: Stopped AP scan as end of AP map has been reached
AP[0]: AHB-AP (IDR: 0x24770011)
AP[1]: JTAG-AP (IDR: 0x02880000)
Iterating through AP map to find AHB-AP to use
AP[0]: Core found
AP[0]: AHB-AP ROM base: 0xE00FF000
CPUID register: 0x410FC241. Implementer code: 0x41 (ARM)
Found Cortex-M4 r0p1, Little endian.
FPUnit: 6 code (BP) slots and 2 literal slots
CoreSight components:
ROMTbl[0] @ E00FF000
ROMTbl[0][0]: E000E000, CID: B105E00D, PID: 000BB00C SCS-M7
ROMTbl[0][1]: E0001000, CID: B105E00D, PID: 003BB002 DWT
ROMTbl[0][2]: E0002000, CID: B105E00D, PID: 002BB003 FPB
ROMTbl[0][3]: E0000000, CID: B105E00D, PID: 003BB001 ITM
ROMTbl[0][4]: E0040000, CID: B105900D, PID: 000BB9A1 TPIU
ROMTbl[0][5]: E0041000, CID: B105900D, PID: 000BB925 ETM
Cortex-M4 identified.
J-Link>
```

Figure 3 – J-Link Commander Output

9. This confirms that the Eval board is properly recognized.
10. While still in the J-Link Commander session, save the Rigado-programmed public MAC address by typing in:
    ```
    savebin mac_addr.bin 0x10001080 8
    ```
11. Exit the J-Link session by typing
    ```
    exit
    ```
12. At this point, a file titled mac_addr.bin will be saved in the current directory. The contents will contain the MAC address in little-endian format:
    ```
    33 22 11 93 54 94 FF FF
    ```
    to correspond to the address `94:54:93:11:22:33`. The last two `FF` values are only fillers to complete the 8-byte read. Rigado MAC addresses begin with the IEEE-assigned company ID (`94:54:93`). The remaining bytes are printed on the 2D and human-readable label on the module. See the MAC Address Provisioning KB article for additional information.
13. This file may be used to restore the MAC address after performing an erase or recover with the J-Link command
    ```
    loadbin mac_address.bin 0x10001080
    ```

5.3 Prepare the module for programming

The BMD-3xx module is shipped from the factory with factory firmware to support legacy designs. This firmware must be removed prior to programming new code. Run the following at a command prompt:

```
nrfjprog -f nrf52 --recover
```

5.4 Open an example project

Note: When selecting examples from the SDK, note the following cross reference:

Rigado Eval Board	Nordic SoC	Compatible Nordic DK
BMD-300-EVAL	nRF52832	PCA10040 / nRF52 DK
BMD-301-EVAL	nRF52832	PCA10040 / nRF52 DK
BMD-350-EVAL	nRF52832	PCA10040 / nRF52 DK
BMD-330-EVAL	nRF52810	PCA10040e / nRF52 DK (If PCA10040e is not available, select PCA10040)
BMD-360-EVAL	nRF52811	PCA10056e / nRF52840 DK (If PCA10056e is not available, select PCA10056)

Table 2 – Rigado EVAL to Nordic DK cross reference

For this guide, the nRF SDK v15.2.0 Heart Rate Service example for the BMD-300-EVAL will be used. The latest SDK version should be used whenever possible. The "nRF5_SDK_xx.x.x_yyyyyyy" directory may change. The folders under usually remain the same from version to version.

1. Navigate to the location of the heart rate example from the SDK, typically
    ```
    <unzipped location>\nRF5_SDK_15.2.0_9412b96\examples\ble_peripheral\ble_app_hrs
    ```
2. Select the DK Board, SoftDevice and IDE directories. Here is the full path:
    ```
    <unzipped
    location>\nRF5_SDK_15.2.0_9412b96\examples\ble_peripheral\ble_app_hrs\
    pca10040\s132\ses
    ```
3. Open the project file (`ble_app_hrs_pca10040_s132.emProject`) to start the Segger Embedded Studio IDE
4. Build the project (`<F7>`)

5. Once the build is successful, you can download the application code onto the module Board
    (`Target | Download ble_app_hrs_pca10040_s132`)
    The first time the board is loaded, both the SoftDevice and the application will be downloaded
    to the BMD-300. Once the SoftDevice is loaded, subsequent downloads will only transfer the
    application. If you need to change SoftDevice versions, repeat section 5.3 Prepare the module
    for programming above.
6. On a mobile device, open the nRF Toolbox application. Select the Heart Rate Monitor.
7. Tap Connect. You should see the Eval board advertising as `Nordic_HRM`.
8. Select this device to see the simulated heart rate being transmitted from the BMD-3xx.

Additional training videos may be viewed here.

6   Hardware Description

Design files for each of the BMD-3xx-EVAL boards may be found on the Rigado website.
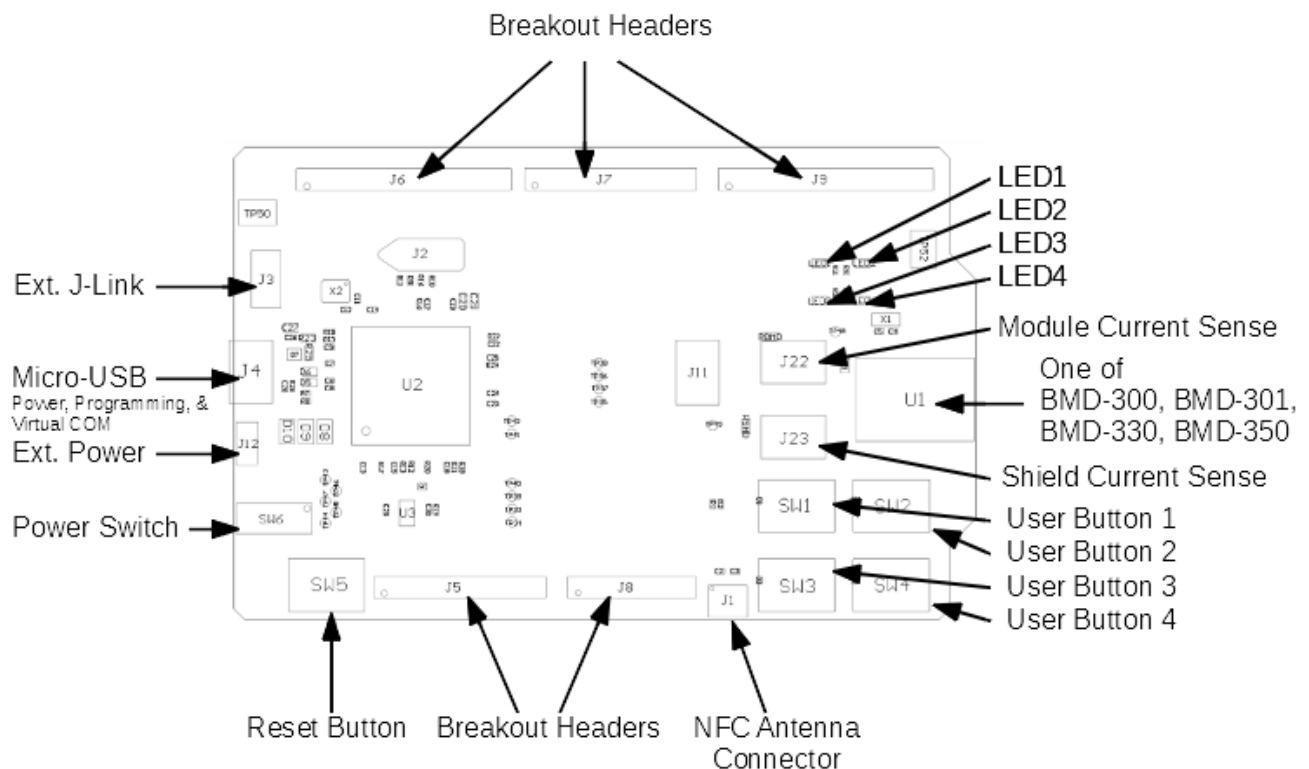

Figure 4 – Assembly Drawing (Top View)

6.1 Power

The BMD-300 Evaluation Board has three possible power sources: USB, a CR2032 coin cell battery, and
a 0.1" through-hole connector. These power sources use protection diodes to prevent reverse voltage
to any supply. This allows them to be used simultaneously. Solder jumpers are provided to allow by-
passing any of the protection diodes eliminating the voltage drop across them. Care should be taken
to not damage the supplies when the protection is by-passed.

6.1.1   Powering the Board:

Typically, power will be provided by USB though VBUS, which will supply +5V to the 3.3V LDO regulator and to the shield connector. The 3.3V LDO regulator will then power the VIO, VSHLD, and VBMD.

When powering the board from the CR2032 coin cell (3VDC) or the external power header, USB can be left disconnected. In this configuration, the interface IC is held in reset to conserve power. *Only if the power protection diodes are left intact, USB can be connected at the same time the coin cell or external power is still applied allowing for easy programming of the module.*
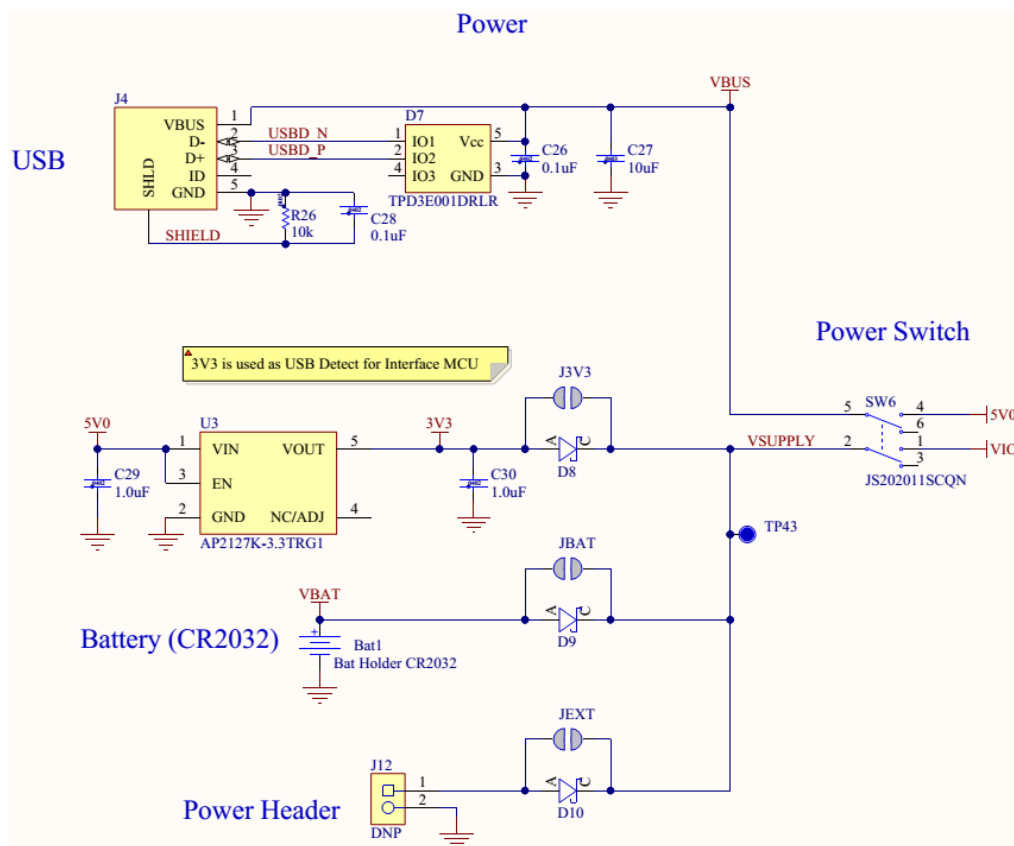

Figure 5 – Schematic – Power Supply

6.2   Reset

The BMD-300 Series module has a configurable hardware reset. However, P0.21 is assumed to be used as the reset pin for all Rigado and Nordic example projects, and thus the evaluation board hardware is configured to use P0.21 as a reset. The Reset button can be configured to connect to an input on the interface IC or to directly connect to P0.21.

The Reset button is connected to the IC used for the J-Link interface by default. Pressing reset while the interface IC is powered will caused a momentary reset signal on the nRESET output of the interface IC, which is connected via solder jumper to P0.21 of the BMD-300 Series module. If the Reset

button is held down during power on, it will cause the interface IC to enter its bootloader mode, allowing either Segger J-Link or mbed programmer firmware to be programmed.

When the Reset button is directly connected to P0.21, it can be used as a 5th user button or as a reset button directly connected to the BMD module.

Solder jumper J21 is used to connect P0.21 of the BMD module to the nRESET net. nRESET is connected to the interface IC and to the reset connections on the Arduino headers.
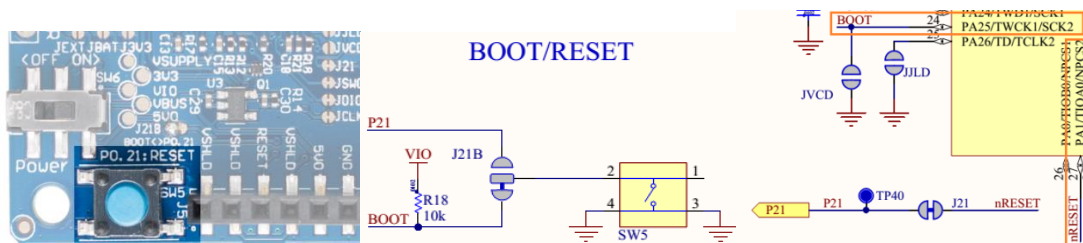

Figure 6 – Schematic – Reset

6.3 Buttons

The Evaluation Board has four user buttons: User 1, User 2, User 3, and User 4. All buttons are active low; they will connect to ground when pressed. The button GPIO pins must be configured with internal pull-up resistors for proper operation when using the user buttons. The buttons and ESD protection can be completely removed from the circuit by breaking the associated jumper.
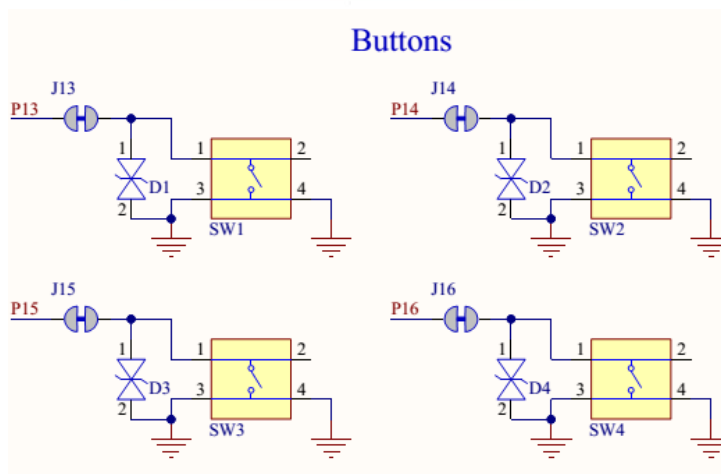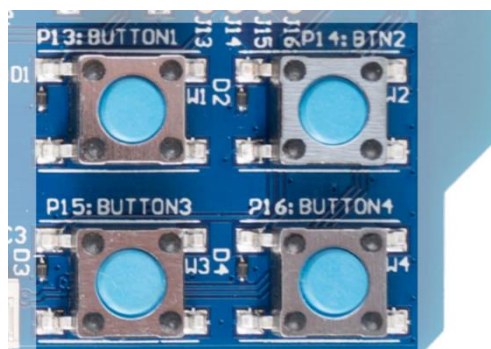

Figure 7 – Schematic – User Buttons

6.4   LEDs

Four User LEDs are provided on the Evaluation Board; two red and two green. LEDs are powered by VIO and are active low. The GPIO should be enabled for high drive when sinking current for the LEDs. The LEDs can be completely removed from the circuit by breaking the associated jumper.
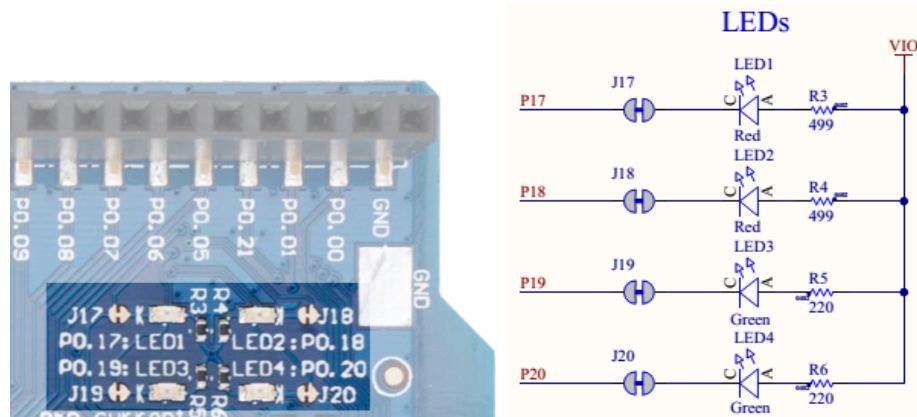

Figure 8 – Schematic – User LEDs

6.5   Virtual COM Port

The evaluation board allows for easy serial communication with the BMD-300 Series Modules and a connected computer. The Interface IC provide a virtual COM USB device that connects to 4 GPIO pins on the module, allowing for UART communication with or without hardware flow control. The UART lines can be completely removed from the circuit by breaking the associated jumpers.

BMD-3xx Pin Name	BMD-3xx Function	Jumper	Interface IC Function
P0.05	RTS	J05	CTS
P0.06	TXD	J06	RXD
P0.07	CTS	J07	TRS
P0.08	RXD	J08	TXD

Table 3 – Virtual COM Port

6.6   32kHz Crystal Oscillator

The evaluation board has a 32.768kHz Crystal Oscillator connected to the BMD-3xx module by default. This allows the module to use any of the three available low frequency (LF) clock sources: an internal calibrated RC oscillator, an internal synthesized clock (derived from the 32MHz clock), or an external crystal oscillator. The external crystal oscillator is the most accurate and lowest power LF clock option. For applications without strict time keeping requirements, the internal calibrated RC oscillator is often suitable. The crystal is connected to the module through a solder select jumper, allowing either the crystal or the IO header to be connected to the module's GPIO pins.
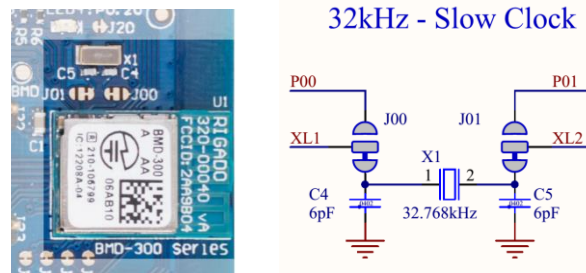
Figure 9 – Schematic - 32KHz Crystal

6.7   NFC Connector

Connection to an external NFC antenna is provided through a Molex flat-flex connector, Part number 051281-0594. Capacitors 'C2' and 'C3' provide tuning of the NFC antenna for resonance at 15.56MHz.

Note: NFC is not supported on the BMD-330. These components are not populated on the BMD_330-EVAL.
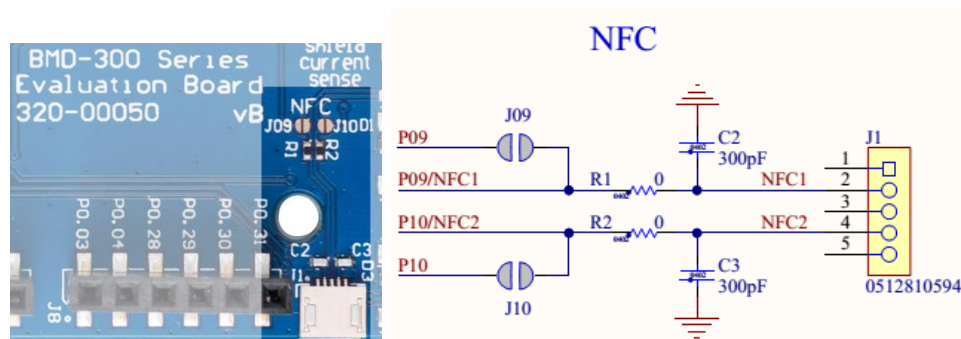

Figure 10 – NFC Connector

6.8   Current Sensing Headers

The evaluation board provides two current sensing headers. 'JBMD' allows for power consumption measurement of the BMD-300 Series Module and 'JSHD' allows for power consumption measurement of shields connected to the Arduino-style headers ('VSHLD' power only).

Each 3-pin 0.1" pitch header has two pins connected across a 1Ω current-sense resistor powering the module or the shield, 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. Current can also be measured directly by removing 'RBMD' / 'RSHD' and using a current meter in series with the two voltage pins. The default hardware configuration does not require any modification of the current sense headers for the BMD-3xx-EVAL to perform properly.

Note: Only current flowing through 'VBMD' into the module is measured; current sunk through GPIO pins is not measured.
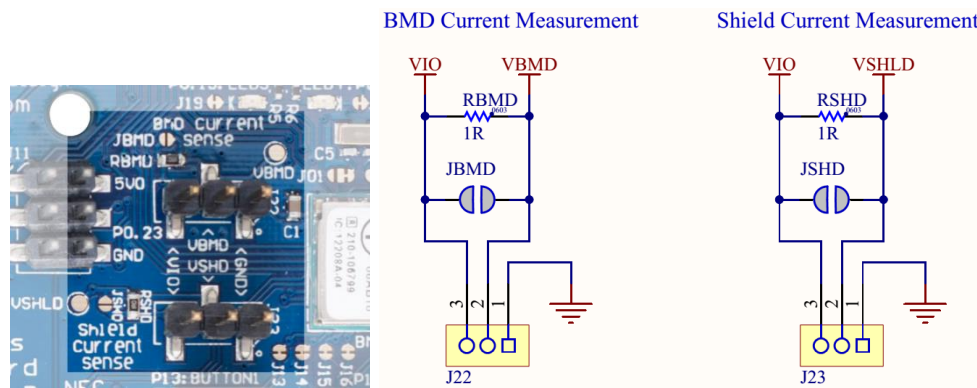
Figure 11 – Current Sensing Header Layout

6.9   External Segger J-Link™ Debug Interface

External target hardware can be connected to J3 for firmware programming and debug. The Segger debug interface is implemented as shown in Figure 12. J3 is implemented with a 2x5 10-pin header on 0.05" centers.
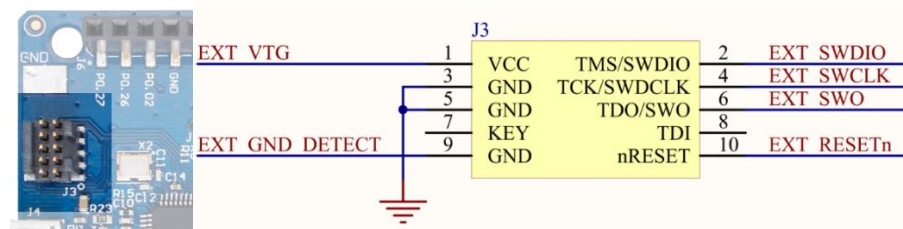

Figure 12 – External J-Link Debug Interface

In order to enable the external J-Link connection, ensure the following are implemented on the target hardware:

- EXT_VTG is used by the debug interface as an input to sense power applied to the external circuit. Only voltages of ~3.0V to ~3.3V are supported. Other operating voltages require the use of an external J-Link Debug Probe. Connect EXT_VTG to the BMD-300 Series power supply (VCC) on the target hardware.

- EXT_GND_DETECT is used by the debug interface to detect the presence of external target hardware. Connect EXT_GND_DETECT to GND on the target hardware.

- Connect EXT_SWDIO and EXT_SWCLK to SWDIO and SWDCLK on the target BMD-3xx, respectively.

- (Optional) Connect EXT_SWO and/or EXT_RESETn to P0.18 and P0.21 on the target BMD-3xx, respectively.

- Connect external power to the target hardware, then connect the BMD-300 Series Evaluation Board to USB.

- At this point, the debug interface will interact with the target hardware instead of the on-board BMD-3xx.

6.10 GPIO Jumpers

There are many solder bridge jumpers on the board available to allow for configurability of the GPIO. Most solder jumpers are used to remove on-board components from the module's GPIO nets, should they interfere with external circuitry added on the I/O headers. All GPIOs are directly connected to the I/O Headers by default, except P0.00 & P0.01 (32kHz crystal) and P0.09 & P0.10 (NFC antenna). These are disconnected from the I/O headers as they would interfere with the default functions.
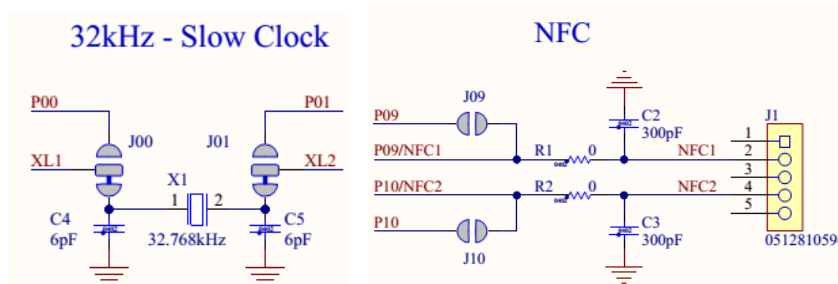

Figure 13 – GPIOs disconnected from I/O headers

The GPIO jumpers are shown on the bottom side of the BMD-300 Series Evaluation Board:

BMD-300 Series			
GPIO	Function	Jumper	HW
P00	XL1	J00	BMD PIN
P01	XL2	J01	
P05	RTS	J05	IF MCU
P06	TXD	J06	
P07	CTS	J07	BMD PIN
P08	RXD	J08	
P09	NFC1	J09 R1	PIN
P10	NFC2	J10 R2	BMD NFC
P13	Button 1	J13	BMD
P14	Button 2	J14	
P15	Button 3	J15	PIN
P16	Button 4	J16	
P17	LED 1	J17	VIO
P18	LED 2	J18	BMD
P19	LED 3	J19	
P20	LED 4	J20	PIN

Figure 14 – GPIO Jumper Summary

6.11 Header Pin-out

Headers J5 through J9 and J11 break-out the IO signals from the BMD-300 on 0.1" pitch headers.
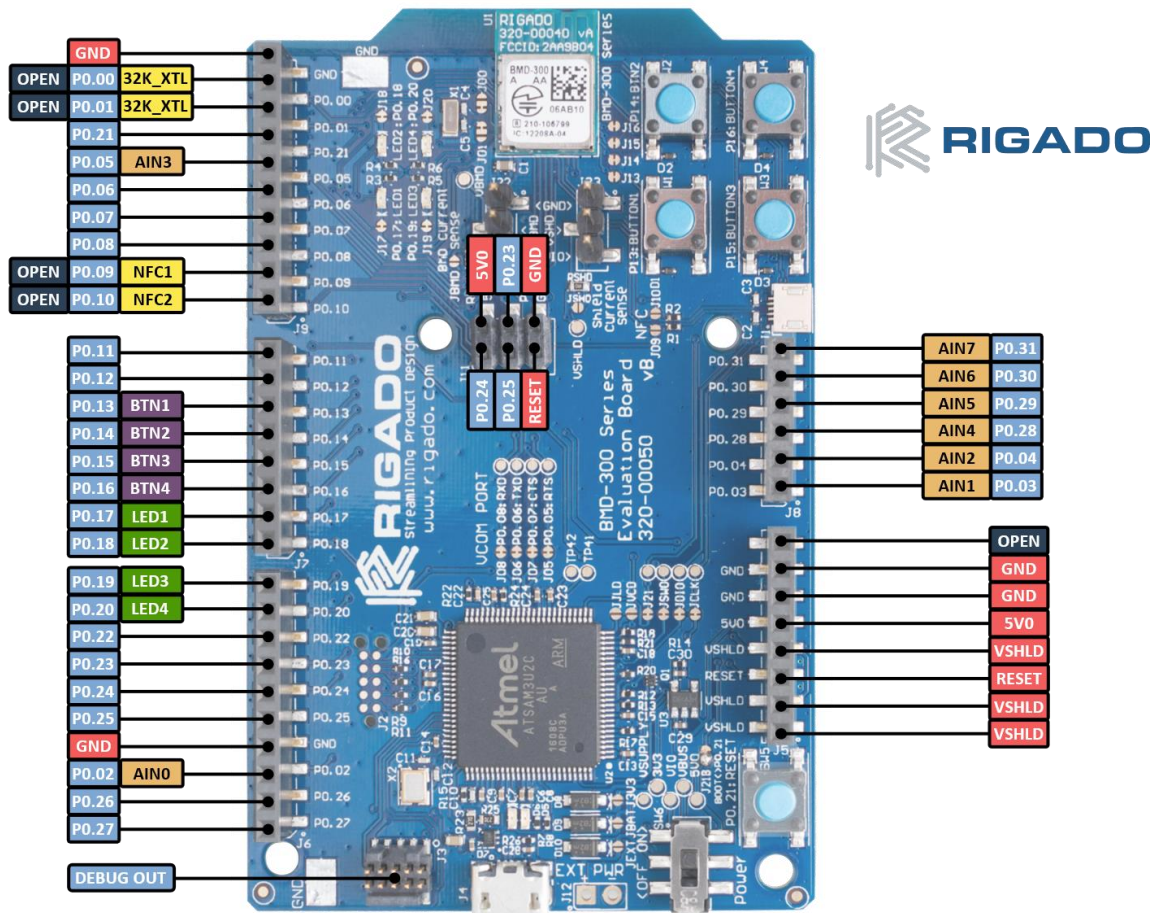

Figure 15 – BMD-300 Series Evaluation Board Pin-out

The tables below are presented relative to the positioning on the BMD-300 Series Evaluation Board

Header J11			
Header Pin	*Pin Name*	*nRF52 Port*	*Function*
1	P0.24	P0.24	GPIO
2	5V0	-	+5.0V USB Power
3	P0.25	P0.25	GPIO
4	P0.23	P0.23	GPIO
5	RESET	P0.21	nRESET
6	GND		Ground

Header J9			
Header Pin	*Pin Name*	*nRF52 Port*	*Function*
10	GND		Ground
9	P0.00	P0.00	OPEN / GPIO
8	P0.01	P0.01	OPEN / GPIO
7	P0.21	P0.21	RESET / GPIO
6	P0.05	P0.05	GPIO / AIN3
5	P0.06	P0.06	GPIO
4	P0.07	P0.07	GPIO
3	P0.08	P0.08	GPIO
2	P0.09	P0.09	OPEN / GPIO
1	P0.10	P0.10	OPEN / GPIO

Header J7			
Header Pin	*Pin Name*	*nRF52 Port*	*Function*
8	P0.11	P0.11	GPIO
7	P0.12	P0.12	GPIO
6	P0.13	P0.13	GPIO
5	P0.14	P0.14	GPIO / TRACED[3]
4	P0.15	P0.15	GPIO / TRACED[2]
3	P0.16	P0.16	GPIO / TRACED[1]
2	P0.17	P0.17	GPIO
1	P0.18	P0.18	GPIO / TRACED[0]

Header J8			
Header Pin	*Pin Name*	*nRF52 Port*	*Function*
6	P0.31	P0.31	GPIO / AIN7
5	P0.30	P0.30	GPIO / AIN6
4	P0.29	P0.29	GPIO / AIN5
3	P0.28	P0.28	GPIO / AIN4
2	P0.04	P0.04	GPIO / AIN2
1	P0.03	P0.03	GPIO / AIN1

Header J6			
Header Pin	*Pin Name*	*nRF52 Port*	*Function*
10	P0.19	P0.19	GPIO
9	P0.20	P0.20	GPIO / TRACECLK
8	P0.22	P0.22	GPIO
7	P0.23	P0.23	GPIO
6	P0.24	P0.24	GPIO
5	P0.25	P0.25	GPIO
4	GND	-	Ground
3	P0.02	P0.02	GPIO / AIN0
2	P0.26	P0.26	GPIO
1	P0.27	P0.27	GPIO

Header J5			
Header Pin	*Pin Name*	*nRF52 Port*	*Function*
8	-	-	
7	GND	-	Ground
6	GND	-	Ground
5	5V0	-	+5.0V USB Power
4	VSHLD	-	+3.3V Shield Power
3	RESET	P0.21	nRESET
2	VSHLD	-	+3.3V Shield Power
1	VSHLD	-	+3.3V Shield Power

Table 4 – Header Pin-Outs

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7   Related Documents

Rigado Documents:

- BMD-300 Data Sheet
- BMD-301 Data Sheet
- BMD-350 Data Sheet
- BMD-330 Data Sheet
- BMD-360 Data Sheet
- MAC Address Provisioning

Nordic Semiconductor Documents:

- nRF52832 Product Specification
- nRF52810 Product Specification
- nRF52811 Product Specification
- S132 SoftDevice Specification
- S112 SoftDevice Specification

8   Life Support and other High-Risk Use Warning

This product is not designed nor intended for use in a life support device or system, nor for use in other fault-intolerant, hazardous or other environments requiring fail-safe performance, such as any application in which the failure or malfunction of the product could lead directly or indirectly to death, bodily injury, or physical or property damage (collectively, "High-Risk Environments"). RIGADO EXPRESSLY DISCLAIMS ANY EXPRESS OR IMPLIED WARRANTY OF FITNESS FOR USE IN HIGH-RISK ENVIRONMENTS. The customer using this product in a High-Risk Environment agrees to indemnify and defend Rigado from and against any claims and damages arising out of such use.

9   Environmental

9.1   RoHS

Rigado's modules are in compliance with Directive 2011/65/EU, 2015/863/EU of the European Parliament and the Council on the restriction of the use of certain hazardous substances in electrical and electronic equipment. The declaration may be found here: https://go.rigado.com/RoHS-Modules

9.2   REACH

Rigado's modules listed below do not contain the 191 SVHC (Substance of Very High Concern), as defined by Directive EC/1907/2006 Article according to REACH Annex XVII. The compliance statement may be found here: https://go.rigado.com/REACH-Modules

9.3   California Proposition 65 (P65)

This product can expose you to Nickel (metallic), which is known to the State of California to cause cancer. For more information go to www.P65Warnings.ca.gov.

10   Contact Information

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13 Document History

Revision	Date	Changes / Notes
1.0	2016-05-04	Initial release
1.0.1	2016-05-06	Added link to reference design files in Section 4, updated logo
1.1	2016-07-28	Updated images, Added section on External J-Link connector, corrected section numbering
1.2	2016-09-09	Added BMD-350-EVAL kit information, document links
1.3	2017-05-09	Corrected BMD-350 hardware kit list
2.0	2018-12-14	Updated to new document format Changed tools to recent Nordic Semiconductor versions
2.1	2019-06-05	Added BMD-360-EVAL kit information, document links Updated Nordic Semiconductor links

Table 5 – Document History