User Guide
Nowi Blue Coral Development Platform

Abstract:

Nowi Blue Coral development platform enables the user to develop for any energy autonomous LTE-M or NB-IoT sensor application. The platform combines Nowi's NH2 Energy Harvesting PMIC together with Nordic Semiconductors nRF9160 cellular modem SiP. The development platform is specifically designed in order to rapidly develop any smart sensor internet of things application that requires cellular connectivity. It is MikroBUS™ compatible which allows over 200+ off-the-shelf sensor development click boards to be used with the platform to develop for any type of sensor application. It includes current measurement capabilities to power profile, and optimize the power consumption of your application.

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1. Introduction

Nowi Blue Coral development platform is a hardware development platform to be used for the design and development of energy autonomous sensor applications that require LTE Cat-M1 or LTE CAT-NB1 connectivity.

The board includes all necessary external circuitry like a SIM card holder and an antenna and it provides the developers access to the NH2 Energy Harvesting PMIC and several hardware peripherals to develop for any type of energy autonomous sensor application.

The key features of this development platform are:

- NH2D0245 energy harvesting PMIC
- nRF9160 cellular SiP
- LTE antenna that supports all bands supported by the SiP
- MikroBUS™ modular header for plug-in sensors and modules
- SIM card socket for nano-SIM (4FF SIM)
- Footprint for eSIM (MFF2 SIM)
- Plug-in PV panel expansion board
- Compatible with most Lithium-Polymer batteries through the Molex 3-pin connector
- Interfaces for nRF9160 and sensor current consumption measurements
- Interfaces for NH2 input and output current measurements

Be cautious when handling the printed circuit board and take any electrostatic discharge precautions where necessary. Waste electronic products should not be disposed of with household waste. Please recycle if the facilities exist. Check with your local authority for recycling advice and policies.

2. Kit Content

The Nowi Blue Coral development platform includes hardware, documentation, hardware schematics, PCB layout files, and PCB manufacturing files.

2.1. Hardware Content

The Nowi Blue Coral development platform contains the development board and a PV panel expansion board. The dimensions of the PV panel expansion board are given in Figure A.1 in Appendix A, this allows the user to design a custom PV panel expansion board in case a different type of PV panel is required. The PV expansion board is symmetrical both of the orientations will work. The polarity of the pins are given in Figure A.1.

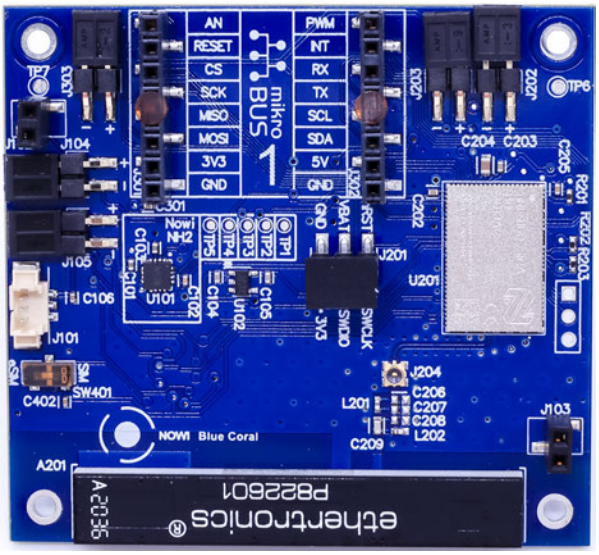

Figure 1: *Blue Coral Development Board*

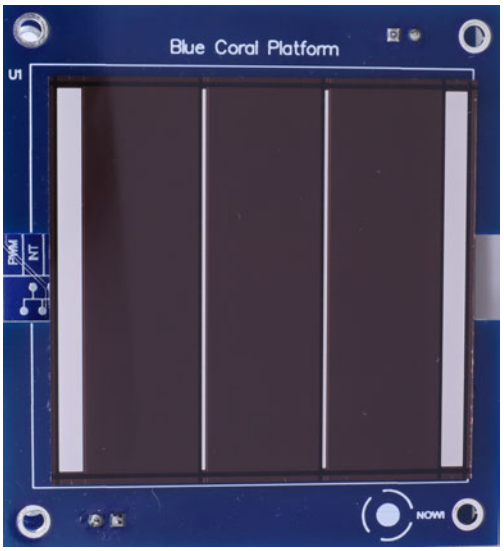

Figure 2: *PV Panel Expansion Board*

Hardware Files
The hardware design files including schematics, PCB layout files, bill of materials, and Gerber files for the Nowi Blue Coral development platform are available on the product page.

2.2. Related Documentation

In addition to the information in this document, you may need to consult other documents.

Additional Documentation

- NH2D0245 Datasheet
- nRF9160 Datasheet
- nRF9160 Product Specification
- nRF9160 AT command manual

3. Hardware Description

The Nowi Blue Coral development platform can be used as a development platform for the NH2D0245 and nRF9160. An onboard connector provides access to the programming and debugging pins of the nRF9160.

3.1. Block Diagram

The Blue Coral development board consists of four main blocks. The power management block, the nRF9160 block, the SIM block, and the MikroBUS™ block. The connections between the different blocks and sub-blocks are shown in figure 3.

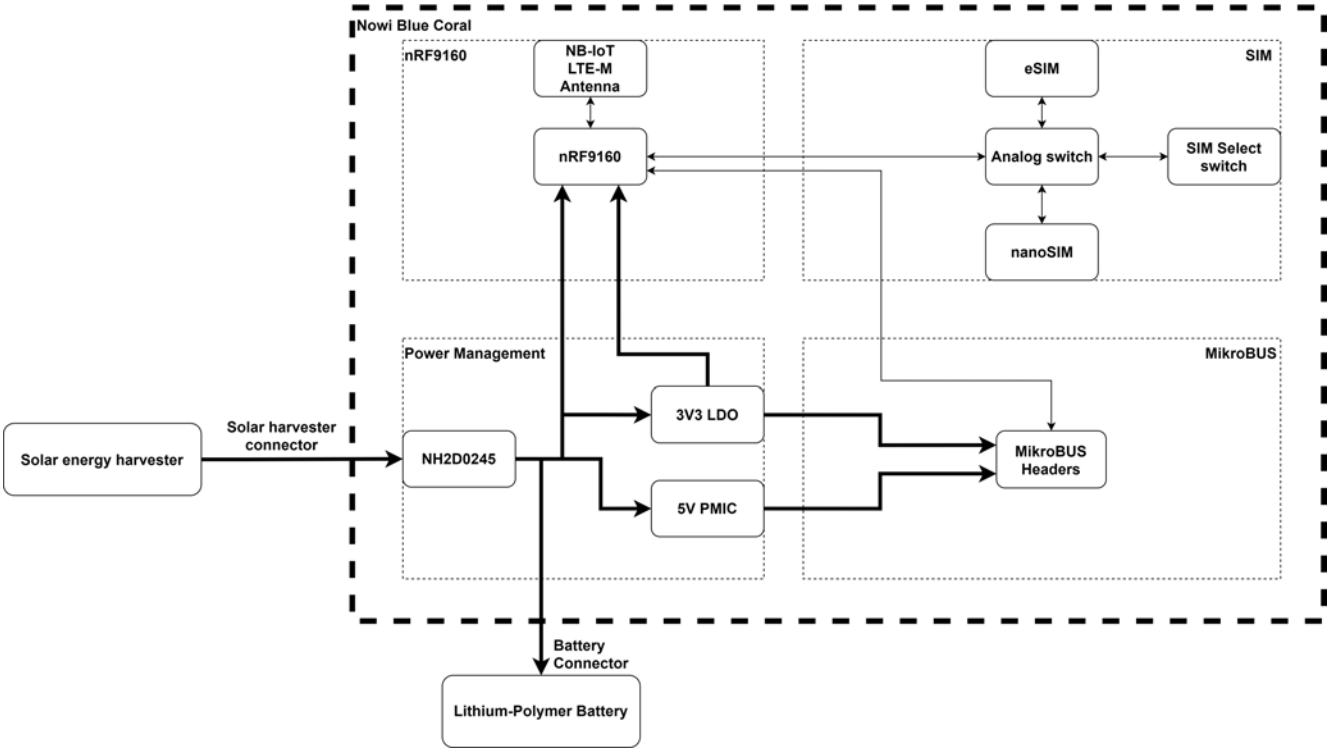

Figure 3: *Blue Coral Board Block Diagram*

3.2. Power Management

The power management section of the Blue Coral development board consists of the Energy Harvesting sub-block using Nowi's NH2D0245 PMIC and several onboard voltage regulators. For each important voltage, there is a voltage test point present on the board.

3.2.1. Energy Harvesting

The Blue Coral development board is intended for the development of energy autonomous sensor nodes powered by photovoltaic harvesters and batteries. A battery connector is provided at connector **J101** (Part no. 53398-0371 from Molex). This battery connector supports most types of Lithium-Polymer batteries, as an example part no. LP-573442-1S-3 from manufacturer Bak. The polarity of the pins of the connector is shown in figure 4. Please note that the middle pin is not connected. Connection to the photovoltaic expansion board is provided at connector **J102**, and connector **J103** provides mechanical stability of the expansion board. The polarity of the PV connector is shown in figure 4. Please note that **J103** is electrically not connected on the board it is just there for mechanical stability. Table 1 gives a brief overview of the PV and battery connectors.

The NH2D0245 has an $\overline{\text{ENABLE}}$ pin that enables or disables conversion. When this pin is logic high it will disable the conversion, and when the pin is logic low it will enable the conversion of the PMIC. It can be used as a means of protecting the battery from overcharging by disabling conversion when the battery voltage crosses a set threshold. The $\overline{\text{ENABLE}}$ pin is connected to pin P0.25 of the nRF9160 cellular module.

Table 1: *Power Supply Related Connectors*

Designator	Functionality	Note
J101	Battery connector	Supports Lithium-Polymer batteries
J102	Expansion board connector	Photovoltaic harvester
J103	Expansion board connector	Mechanical stability

There are several voltage test points present on the board to measure and test voltages that are related to the energy harvesting part. **TP1** is a voltage test point for the input voltage of the NH2D0245. **TP2** is a voltage test point for the battery voltage. **TP3** is a test point for the system ready pin of the NH2D0245 PMIC, when this voltage is equal to the battery voltage it means that the PMIC started up successfully. A summary of these voltage test points is also given in table 2.

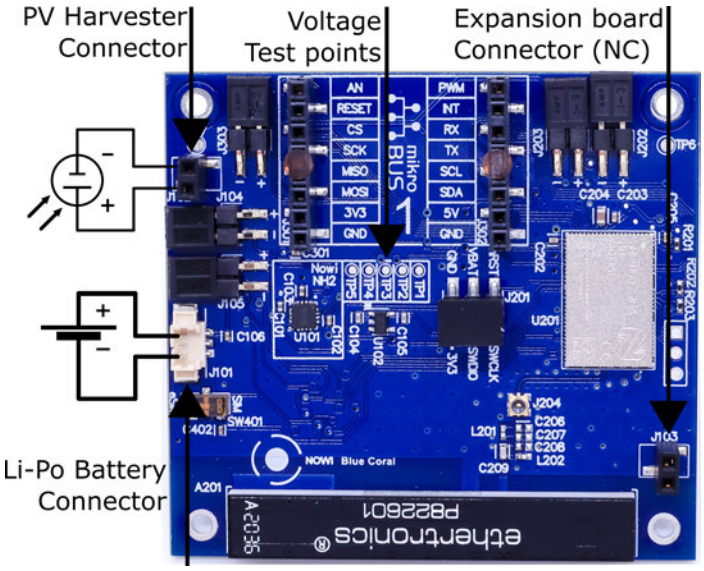

Figure 4: *Power Management Blue Coral Board*

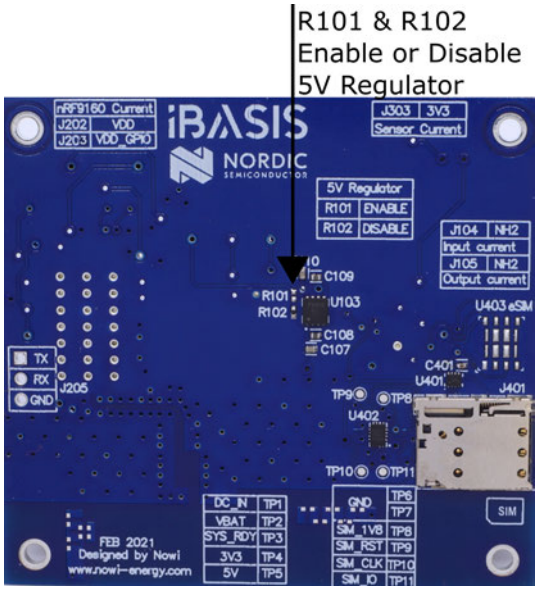

Figure 5: *Bottom Side 5 V Regulator*

The NH2 can be configured for outdoor and indoor solar harvesting on the Blue Coral Board. The board is standard set to outdoor solar harvesting and the delivered PV panel is optimized for outdoor environments. In order to use lower power indoor solar harvesting you have to remove the resistor jumper **R104** and solder it on the footprint of resistor jumper **R103**. Resistor jumper **R104** connects the **PWRS**, **R0**, **R1**, and **R2** pins to **VBAT**. Resistor jumper **R103** connects these pins to **GND**. The resistor jumpers can be found in the silkscreen box with the Nowi NH2.

3.2.2. On-board Voltage Regulators

The Blue Coral development board has two onboard voltage regulators that regulate the battery voltage to 3.3 V and 5 V. The 3.3 V can be measured at test point **TP4** and the 5 V can be measured at test point **TP5**. These test points are also shown in figure 4. The 5 V voltage regulator is normally disabled. To enable the voltage regulator please move the 0 Ohm jumper from R102 to R101, the location of these jumpers is shown in figure

5. All the test points related to the power supplies and energy harvesting section of the board are summarized in table 2.

Table 2: *Power Supply Related Voltage Test Points*

Designator	Functionality	Note
TP1	DC_IN	DC input voltage test point
TP2	VBAT	Battery voltage test point
TP3	SYS_RDY	System ready test point
TP4	3V3	3.3 V test point
TP5	5 V	5 V test point
TP6	GND	Reference ground
TP7	GND	Reference ground

3.3. nRF9160 Cellular IoT Module

The Blue Coral development board houses an nRF9160 cellular IoT chipset from Nordic Semiconductor. The development board has an onboard antenna that supports most NB-IoT and LTE-M frequency bands. There is a microwave coaxial connector present to measure the RF performance of the module, the connector has a typical 50 Ohm impedance. Several pins of the nRF9160 are connected to peripherals. These pins and functionalities are summarized in table 3.

Table 3: *nRF9160 Pins and Functionalities*

nRF9160 pin	Functionality	Note
P.00	nRF91 UART2 RX	UART RX for the MikroBUS™ header
P.01	nRF91 UART2 TX	UART TX for the MikroBUS™ header
P.08	INT	Interrupt pin for the MikroBUS™ header
P.09	PWM	Pulse width modulation compatible pin for the MikroBUS™ header
P.10	SPI CS	SPI chip select for the MikroBUS™ header
P.11	SPI MOSI	SPI master out slave in for the MikroBUS™ header
P.12	SPI MISO	SPI master in slave out for the MikroBUS™ header
P.13	SPI SCK	SPI clock for the MikroBUS™ header
P.14	AN	Analog compatible pin for the MikroBUS™ header
P.17	RESET	GPIO to reset the MikroBUS™ device
P.25	$\overline{\text{ENABLE}}$	Pin to enable or disable the NH2D0245 PMIC
P.28	nRF91 UART1 RX	UART RX for header J205
P.29	nRF91 UART1 TX	UART TX for header J205
P.30	I2C SDA	I2C dataline, connected to MikroBUS™ header
P.31	I2C SCL	I2C clockline, connected to MikroBUS™ header

3.4. NanoSIM & eSIM

The Blue Coral development board supports both nanoSIM (4FF SIM) and eSIM (MFF2 SIM), and an onboard slide switch allows the user to switch between eSIM and nanoSIM. Figure 6 shows the location of the switch for the SIM, with this switch the board can be set for SIM or eSIM. Figure 7 shows the location of the SIM holder, eSIM footprint, and SIM signal test points on the bottom of the board.

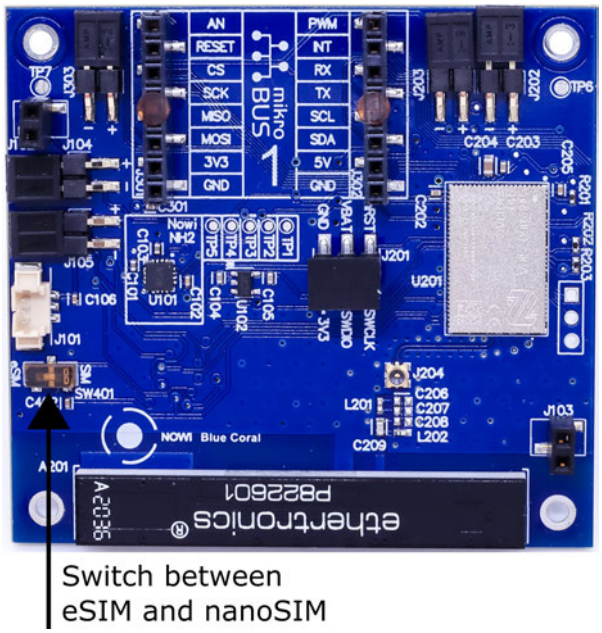

Figure 6: *SIM Switch Location*

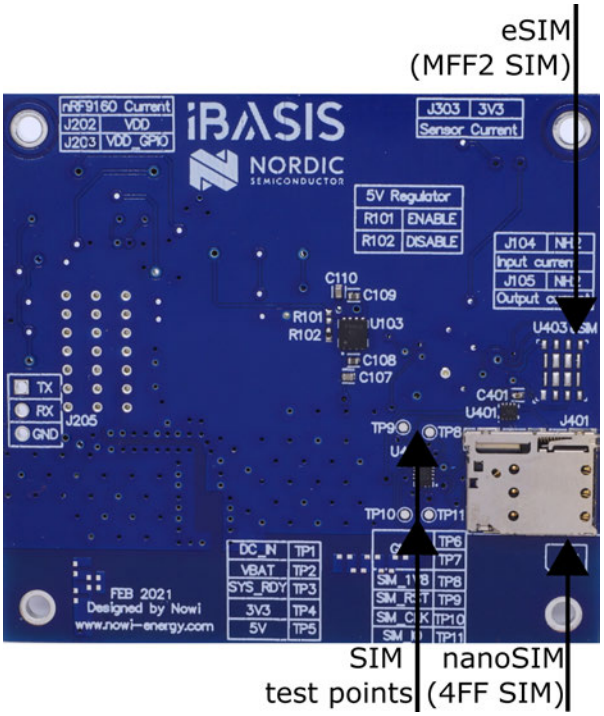

Figure 7: *eSIM, nanoSIM and SIM Test Point Locations*

3.5. MikroBUS™ Socket

The Blue Coral development board has one MikroBUS™ socket. This modular socket can be used to connect a MikroBUS™ sensor Click board. The pin connections between the MikroBUS™ socket header **J301** and the nRF9160 module are summarized in table 4, and the pin connections between MikroBUS™ socket header **J302** and the nRF9160 module are summarized in table 5. Please note that the 5 V in connector **J302** is normally disabled. This voltage regulator can be enabled by moving resistor jumper R102 to footprint R101 as shown in figure 5.

Table 4: *MikroBUS™ Socket Header J301 Connections*

Designator	Functionality	nRF9160 GPIO Pin
AN	Analog compatible pin	P.14
RESET	Reset of MikroBUS™ device	P.17
CS	SPI chip select	P.10
SCK	SPI clock	P.13
MISO	SPI master in slave out	P.12
MOSI	SPI master out slave in	P.11
3V3	3V3 supply for MikroBUS™ device	NA
GND	Reference ground	NA

Table 5: *MikroBUS™ Socket Header J302 Connections*

Designator	Functionality	nRF9160 GPIO Pin
PWM	Pulse width modulation compatible pin	P.09
INT	Interrupt compatible pin	P.08
RX	nRF9160 UART2 RX	P.00
TX	nRF9160 UART2 TX	P.01
SCL	I2C clock line	P.31
SDA	I2C data line	P.30
5V	5 V supply for MikroBUS™ device, normally disabled	NA
GND	Reference ground	NA

3.6. PCB Layout

Figures 8 and 9 show the top and bottom layout of the Blue Coral development board.

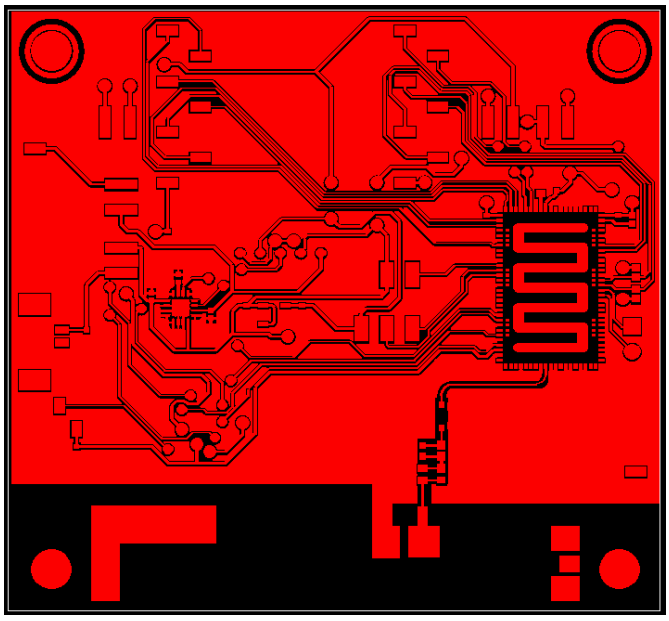

Figure 8: *Top Layer PCB Layout*

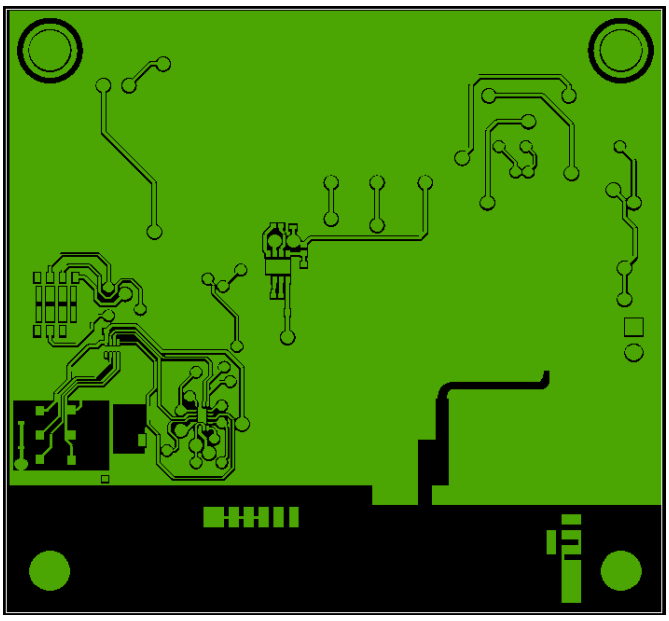

Figure 9: *Bottom Layer PCB Layout*

4. Firmware Development

The nRF9160 uses ARM's SWD interface to flash the chip with firmware. These signals together with the 3.3 V supply as well as the battery supply are exposed at connector **J201**. Table 6 shows which pin corresponds to which functionality. Figure 10 shows the location of the connector on the board.

Table 6: *Connector J201 Pinout*

Pin	Functionality	Pin	Functionality
6	nRESET	5	SWDCLK
4	VBAT	3	SWDIO
2	GND	1	3V3

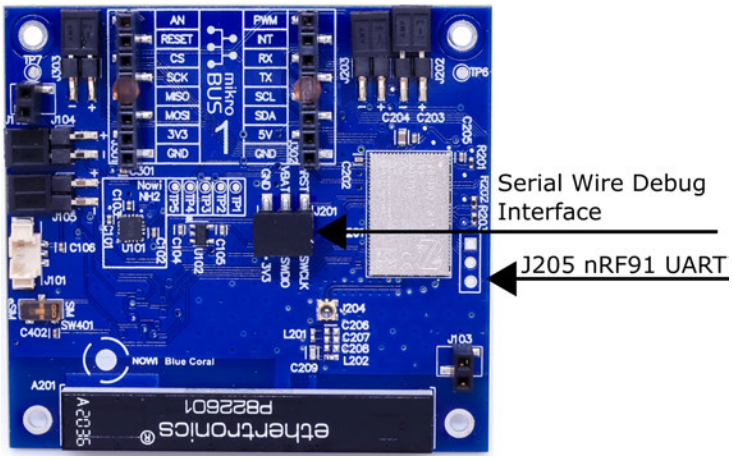

Figure 10: *SWD and UART Interface*

An extra UART connection is exposed at connector **J205**. This connector is not populated and can be used as an extra means of debugging through the serial COM port of the PC using a serial to USB converter device. Table 7 shows which pin corresponds to which functionality. Figure 10 shows the location of this connector, this connector is normally not populated.

Table 7: *Connector J205 Pinout*

Pin	Functionality
1	nRF9160 UART1 TX
2	nRF9160 UART1 RX
3	GND

5. Voltage Test Points

The Blue Coral board has several voltage test points. These voltage test points are summarized in table 8.

Table 8: *Voltage Test Points*

Designator	Signal	Functionality
TP1	DC_IN	DC input voltage of the NH2D0245
TP2	VBAT	Battery supply voltage
TP3	SYS_RDY	System ready signal of the NH2D0245, system ready indicates if the chip has started up
TP4	3V3	The 3.3 V power supply
TP5	5 V	The 5 V power supply normally disabled
TP6	GND	Reference ground
TP7	GND	Reference ground
TP8	SIM_1V8	1.8 V supply of the nanoSIM and eSIM
TP9	SIM_RST	Reset signal of the nanoSIM and eSIM
TP10	SIM_CLK	Clock signal of the nanoSIM and eSIM
TP11	SIM_IO	Data signal of the nanoSIM and eSIM

6. Measuring Current

There are several connectors present on the board to measure the currents of the system. The current measurement connectors are summarized in table 9. The location of the current measurement connectors is shown in figure 11.

NH2D0245

To measure the input current of the NH2D0245 energy harvesting PMIC a current meter can be attached to connector **J104**. To measure the output current of the NH2D0245 energy harvesting PMIC a current meter can be attached to connector **J105**.

nRF9160

To measure the supply current of the nRF9160 a current meter can be attached to connector **J202**. To measure the GPIO current of the nRF9160 a current meter can be attached to connector **J203**.

3V3 Sensor

To measure the supply current of the 3V3 sensor a current meter can be attached to connector **J303**.

Table 9: *Current Measurement Connectors*

Pin	Functionality
J104	NH2D0245 Input current
J105	NH2D0245 Output current
J202	nRF9160 supply current
J203	nRF9160 GPIO current
J303	3V3 Sensor current

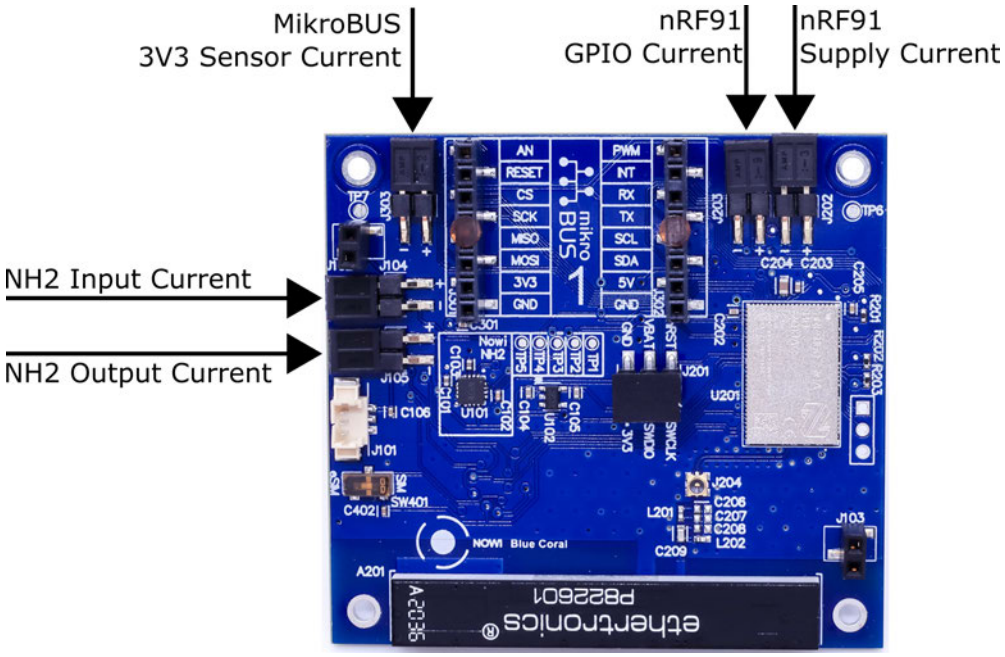

Figure 11: *Current Measurement Interfaces*

7. RF Measurements

The Blue Coral development board is equipped with a small microwave coaxial connector **J204** of SWF type for measuring the RF signal of the nRF9160 for LTE-M and NB-IoT (Part no. MM8130-2600 from Murata Electronics). The location of this connector is shown in figure 12.

The connector has an internal switch. By default, when no RF measurement cable is attached, the RF signal is connected to the onboard antenna. When the cable is attached to the connector, there will be an open circuit between the nRF9160 and the antenna. An adapter is available (Part no. MXHS83QE3000 from Murata Electronics) which has a standard SMA connection on the other end for connecting RF measurement instruments, this adapter is not included in the kit.

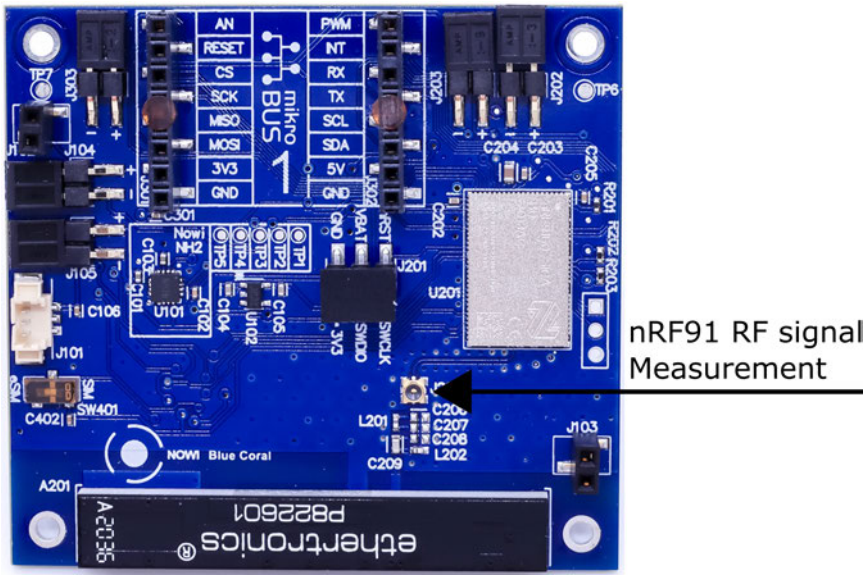

Figure 12: *RF Measurement Interface*

8. Glossary

MikroBUS™ Socket
Embedded development socket that follows the MikroBUS™ pinout as described in the design specification of MikroE.

LTE Cat-M1
Long Term Evolution, category M1. This technology is for Internet of Things devices to connect directly to a 4G network, without a gateway, and on batteries.

Cat-NB1
Narrowband Internet of Things, a Low Power Wide Area technology used to connect devices to the internet using existing mobile networks.

9. Acronyms and Abbreviations

These acronyms and abbreviations are used in this document.

I2C
Inter-integrated circuit

UART
Universal Asynchronous Receiver-Transmitter

SPI
Serial Peripheral Interface

GPIO
General Purpose Input Output

SWD
Serial Wire Debug

SIM
Subscriber Identification Module

eSIM
embedded Subscriber Identification Module

LTE-M
Long Term Evolution for Machines

NB-IoT
Narrowband Internet of Things

PMIC
Power Management Integrated Circuit

RF
Radio Frequency

Li-Po
Lithium-Polymer

SiP
System in Package

PCB
Printed Circuit Board

10. Legal Notices

Any information in this document is preliminary and subject to changes without prior notice. Any information in this document is Nowi B.V. proprietary property and is protected by copyright and trademark laws and other intellectual property rights.

Nowi B.V. is willing to supply limited numbers of Blue Coral development boards and associated documents to the Customer. It is agreed that parts and documentation will be supplied under Nowi B.V Terms of Supply. Parts and documents will be supplied "as is". Nowi B.V does not warrant to the Customer that either is free from faults or defects or is of satisfactory quality or fit for any particular purpose.

Appendix A: PV Panel Expansion board Dimensions

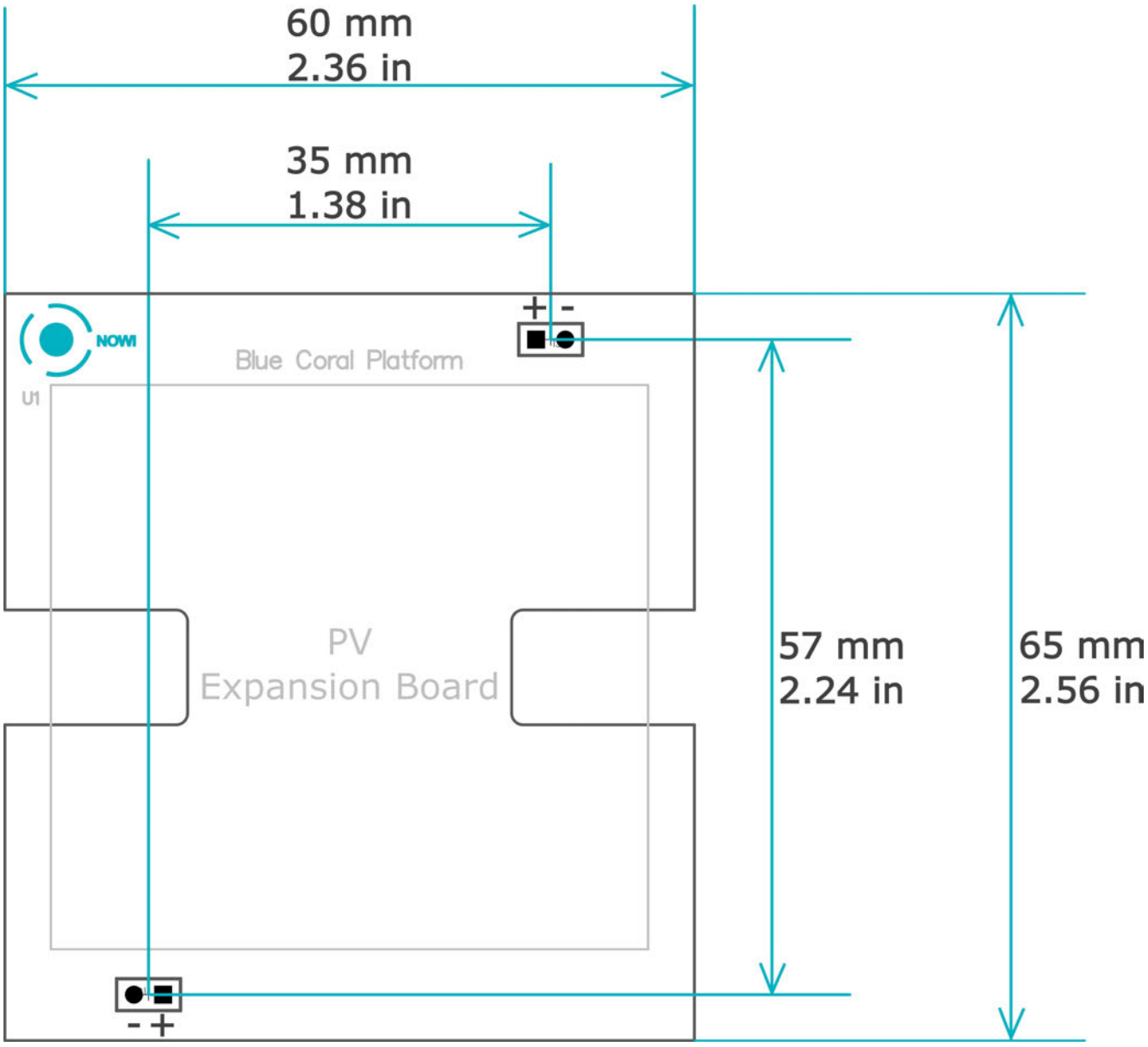

Figure A.1: *PV Add On Board Dimensions*