nRF9151 DK Hardware

v.0.9.0

User Guide

4536_001 / 2024-08-29

Contents

Revision history

Date	Description
August 2024	First release

Environmental and safety notices

Environmental and safety notices for the DK and power supply requirements.

> **Note:** The nRF9151 DK must be powered by a PS1 class (IEC 62368-1) power supply with maximum power less than 15 W.

Skilled persons

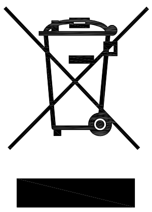
The nRF9151 DK is intended for use only by skilled persons.

A skilled person is someone with relevant education or experience that enables them to identify potential hazards and takes appropriate action to reduce the risk of injury to themselves and others.

Electrostatic discharge

The nRF9151 DK is susceptible to *Electrostatic Discharge (ESD)*.

To avoid damage to your device, it should be used in an electrostatic free environment, such as a laboratory.



Environmental Protection

Waste electrical products should not be disposed of with household waste.

Please recycle where facilities exist. Check with your local authority or retailer for recycling advice.

1 Introduction

The nRF9151 DK is a hardware development platform used to design and develop application firmware on the nRF9151 *System in Package (SiP)*. The nRF9151 SiP supports *DECT NR+* or *Long-Term Evolution (LTE)* and *Global Navigation Satellite System (GNSS)* depending on the installed network protocol firmware.

The *Development Kit (DK)* includes all necessary circuitry, such as antennas and a *Subscriber Identity Module (SIM)* card holder, and provides developers access to all I/O pins and relevant module interfaces.

To get started with the nRF9151 DK, install nRF Connect for Desktop and from there install the Quick Start app.

Key features

- nRF9151 SiP
- 3GPP LTE release 14 *Cat-M1* compliant
- 3GPP LTE release 14 *Cat-NB1* and *Cat-NB2* compliant
- DECT NR+ bands: 1, 2, 9
- Onboard LTE/DECT NR+ antenna which supports all bands supported by the SiP
- Onboard GNSS antenna
- Buttons and LEDs for user interaction
- I/O interface for Arduino form factor plug-in modules
- SEGGER J-Link OB Debugger with debug out functionality
- *Universal Asynchronous Receiver/Transmitter (UART)* interfaces through virtual serial ports
- USB connection for debugging and programming and power
- SIM card socket for nano-SIM (4FF SIM)
- Interfaces for nRF9151 current consumption measurements

2 Kit content

The nRF9151 DK includes hardware, preprogrammed firmware, documentation, hardware schematics, and layout files.

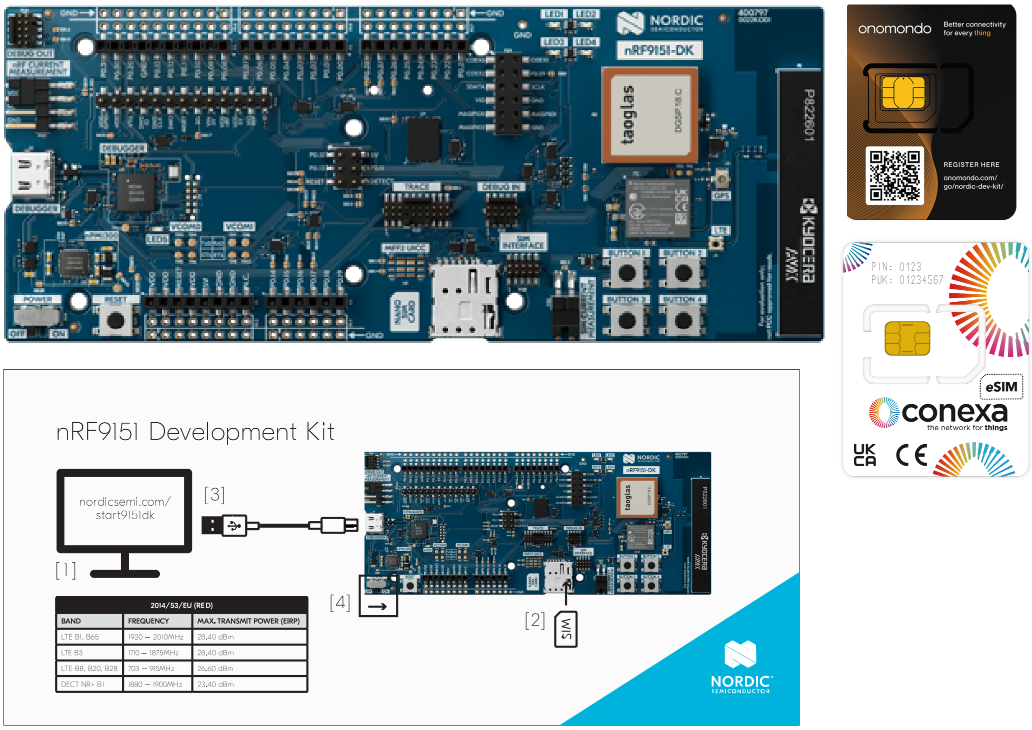


Figure 1: nRF9151 DK kit content

Hardware files

The hardware design files include the following resources:

- Schematics
- PCB layout files
- Bill of materials
- Gerber files

3 Operating modes

The nRF9151 DK has two main modes of operation.

3.1 Firmware development mode

The primary interface for programming and debugging the nRF9151 DK is the *Universal Serial Bus (USB)* port (**J6**). The USB port is connected to an interface MCU which embeds a SEGGER J-Link-OB (Onboard) debug probe.

The following figure shows the interfaces used in firmware development mode.

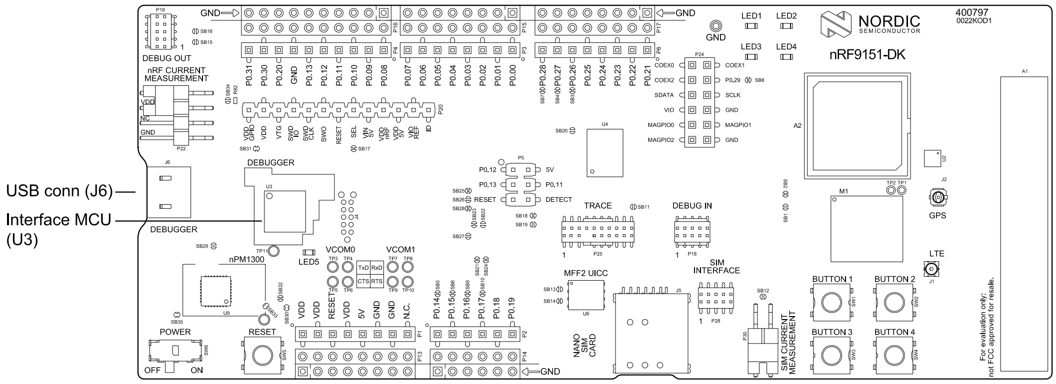


Figure 2: Firmware development mode

3.1.1 Device programming

The nRF9151 DK supports *Serial Wire Debug (SWD)* programming interfaces for onboard and off-board nRF targets.

The primary target for programming and debugging in the *DK* is the nRF9151 *SiP*. The interface MCU also supports programming external nRF devices fitted on a shield or through a connector to external boards such as the user's own prototypes.

The interface MCU automatically detects connected external targets.

3.1.2 Virtual serial port

The interface MCU features *UART* interfaces through two virtual serial ports.

The virtual serial ports are the following:

- VCOM0 – Connected to the nRF9151 *SiP* UART1
- VCOM1 – Connected to the nRF9151 SiP UART2

The virtual serial ports have the following features:

- Flexible baud rate settings up to 1 Mbps
- *Request to Send (RTS)*/*Clear to Send (CTS)*-style *Hardware Flow Control (HWFC)*

Note: Baud rate 921600 is not supported through the virtual serial port.

3.1.3 Reset

The nRF9151 DK is equipped with a RESET button (**SW5**).

By default, the RESET button is connected to the interface MCU and an analog switch *Integrated Circuit (IC)*. The RESET signal is forwarded from the interface MCU to the nRF9151 *SiP* or any device connected to the external debugging and programming connectors.

3.2 Performance measurement mode

The nRF9151 DK has flexible configuration options for performance testing and operation analysis. The combination of solder bridges and parameter settings in the interface MCU define the DK's operation mode.

3.2.1 USB detect

To detect when the interface MCU *USB* is connected, there is a circuit sensing the VBUS of the USB connector **J6**.

When the USB cable is connected, the VDD is propagated to the USB_DETECT signal.

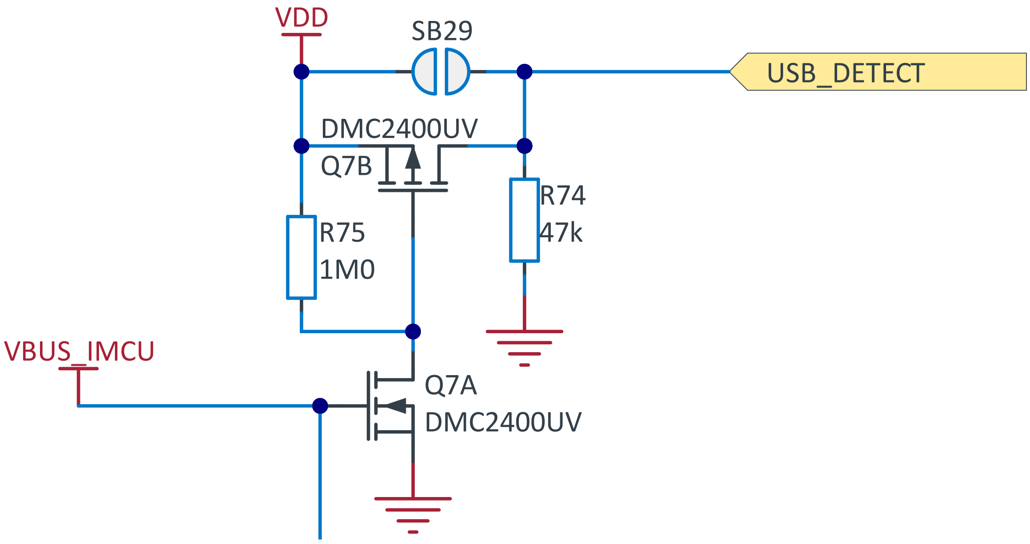


Figure 3: USB detect switch

4 Hardware description

The nRF9151 DK features an onboard programming and debugging solution.

4.1 Hardware drawings

The nRF9151 DK hardware drawings show both sides of the *DK*.

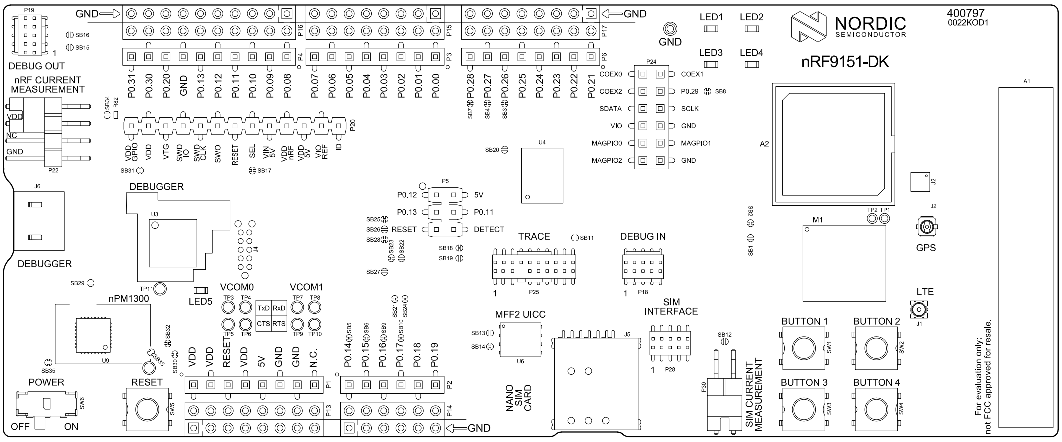


Figure 4: nRF9151 DK, front view

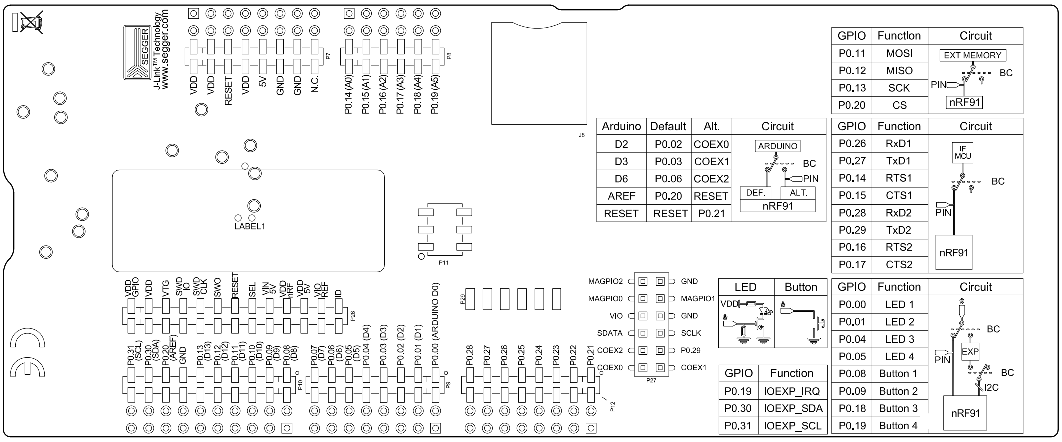


Figure 5: nRF9151 DK, back view

4.2 Block diagram

The block diagram illustrates the functional architecture of the nRF9151 DK.

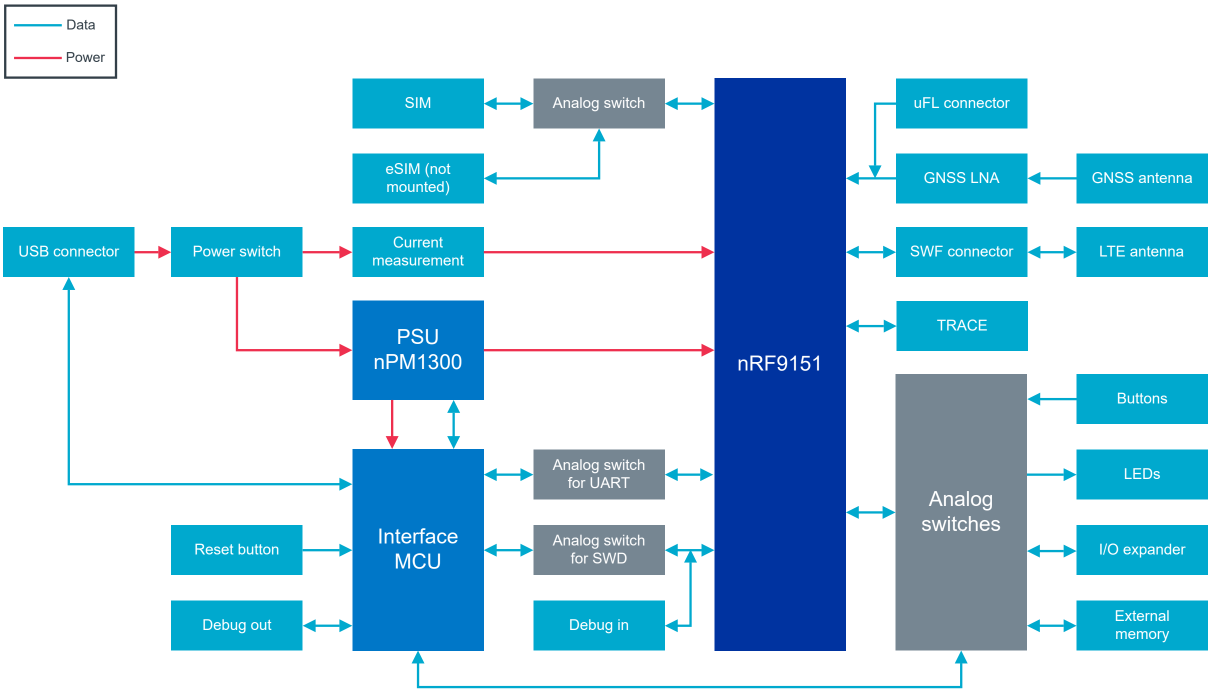


Figure 6: nRF9151 DK block diagram

4.3 Power supply

The *DK* has a flexible and configurable power supply system to allow software development and testing using different power sources and to facilitate accurate power consumption measurements.

The nRF9151 DK is powered by either of the following sources:

- USB connector **J6** (5 V)
- External supply on pin **`VIN 5V`** of connector **P20**

The DK is primarily powered by 5 V from the USB connector **J6**. Alternatively, the DK can be powered by the **`VIN 5V`** pin located on the **P20** header. Both sources support voltages in the range of 4.0 V to 5.5 V with a nominal voltage of 5 V. The DK must be powered by only one source at a time.

> **Note:** By default, a jumper is placed between the **`VDD_5V`** and **`VDD_nRF`** pins on connector **P22**. This ensures power supply to the nRF9151 *SiP*.

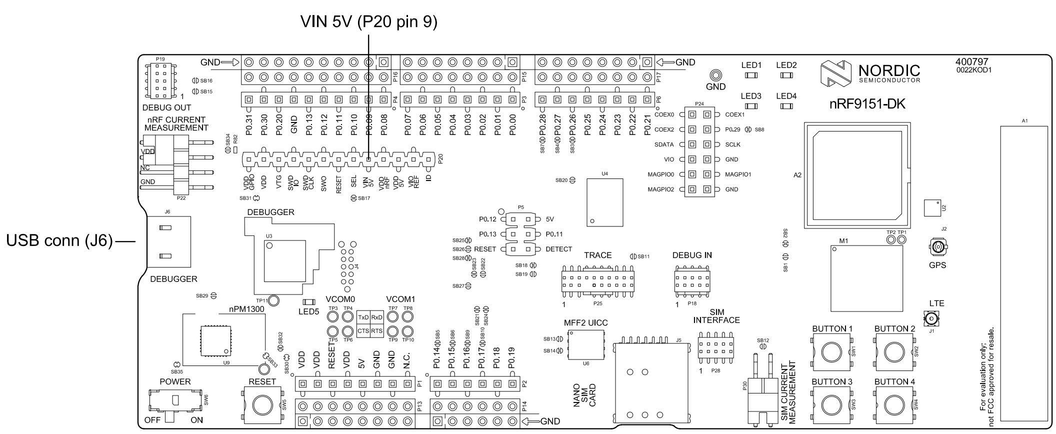


Figure 7: Power supply options

By default, the nRF9151 SiP is supplied from USB through a jumper. To supply other power domains on the board, nPM1300 *IC* is used. The output voltage of the nPM1300 can be controlled through the board controller. The startup voltage for BUCK1 can be set with resistor R36 and for BUCK 2 with resistor R37.

For more information, see Board control on page 14 and Output voltage selection in nPM1300 Product Specification.

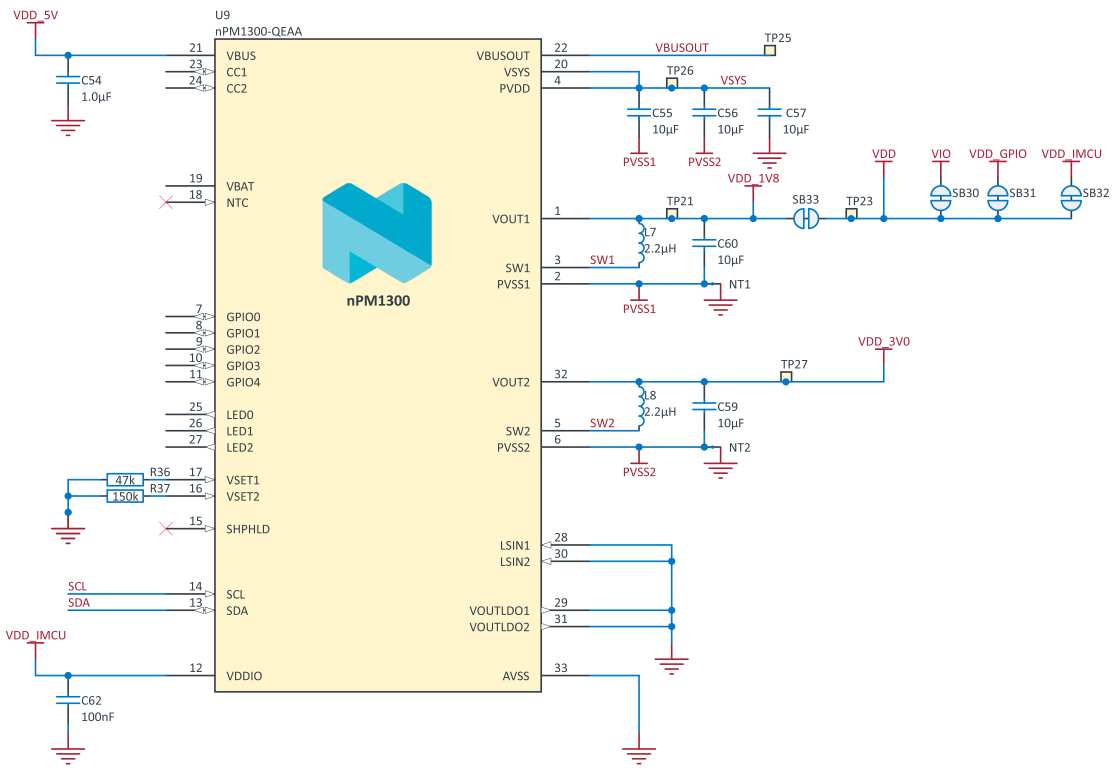


Figure 8: Power management solution

4.3.1 nRF9151 SiP supply rail

The nRF9151 *SiP* has a supply range of 3.0 V to 5.5 V and is directly powered by the VDD_nRF supply rail.

Powering through VDD_nRF supplies only the nRF9151 SiP.

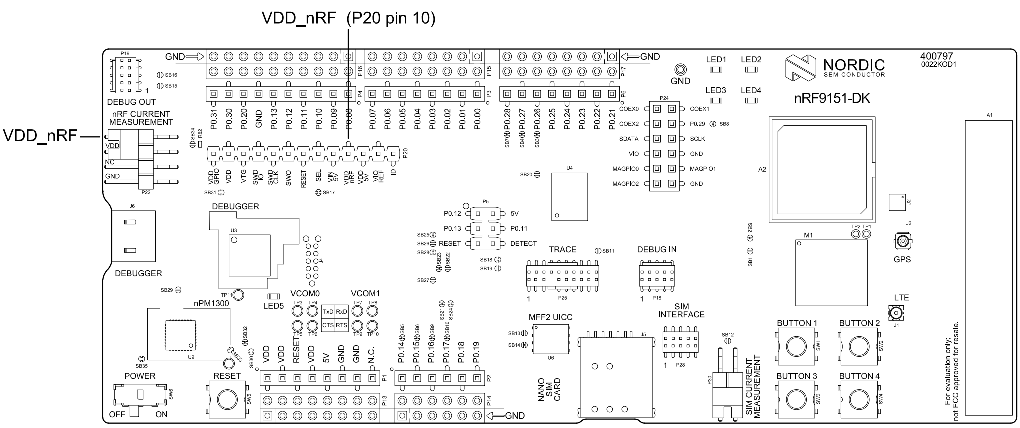


Figure 9: VDD_nRF

For more information, see Current measurement on page 30.

4.4 Antenna interfaces

The nRF9151 DK has antenna interfaces for *LTE* and *GNSS*. *DECT NR+* uses the same on-board antenna as LTE.

The LTE signal is propagated through a coaxial connector with a switch that disconnects the antenna from the radio if an adapter cable is connected. This makes it possible to perform conducted measurements or to attach external antennas to the radio.

The GNSS signal is RX only. A *Low-Noise Amplifier (LNA)* with integrated filters amplifies and filters the signal before it is fed to the GNSS RF port on the nRF9151 DK. An external active GNSS antenna can be connected to **J2**. When using an external antenna, the LNA should be disabled.

The DK has the following antenna interface connectors:

- **J1** – Connector with a switch for the LTE antenna (**A1**)
- **J2** – Connector for an external GNSS antenna

For more information on the GNSS antenna interface, see GNSS on page 13.

4.5 GNSS

The nRF9151 DK has a dedicated *GNSS* port to support global navigation. GNSS functionality requires support in the onboard network protocol firmware.

The GNSS signal is received from the onboard or external active GNSS antenna. The onboard antenna (**A2**) is connected to the *LNA* (**U2**).

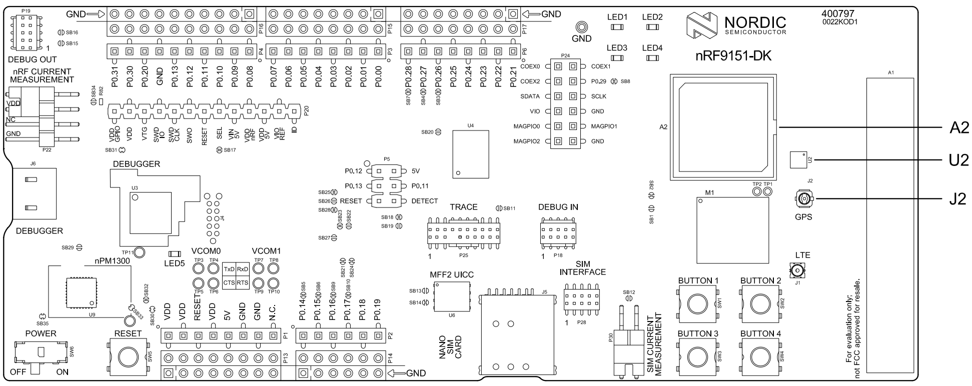


Figure 10: Onboard GNSS antenna (A2), LNA (U2), and connector J2

The GNSS signal from the onboard antenna is amplified and filtered in the LNA (**U2**), which has an integrated prefilter and postfilter, before it is fed to the nRF9151 DK. This makes the GNSS receiver more sensitive to GNSS signals and less sensitive to interference from other sources on the *DK* or nearby. The LNA is enabled by a GNSS-enable signal from the nRF9151 DK using the **`COEX0`** pin.

An external active GNSS antenna can be connected to the *U.FL* connector **J2**. The default 3.0 V *DC* is fed through **J2** to supply the LNA of the external antenna. The voltage can be changed through the board controller. When using an external GNSS antenna, the onboard GNSS LNA (**U2**) must be disabled to avoid interference. This is done by ensuring that the VEN signal is low and set by the **`%XCOEX0`** *AT command*.

To optimize GNSS reception, do the following:

- GNSS signals do not usually penetrate ceilings or other structures that well. For best GNSS performance, the DK should be placed outside on a flat surface in an open space far from sources of interference and other structures that can block the satellite signals.

- The Molex patch antenna achieves the highest gain when placed horizontally on a surface (x-y) facing the z-axis since it can receive all propagated GNSS signals. A lower gain is experienced if the patch antenna is mounted at an angle.

The following figure shows the nRF9151 DK's GNSS circuitry.

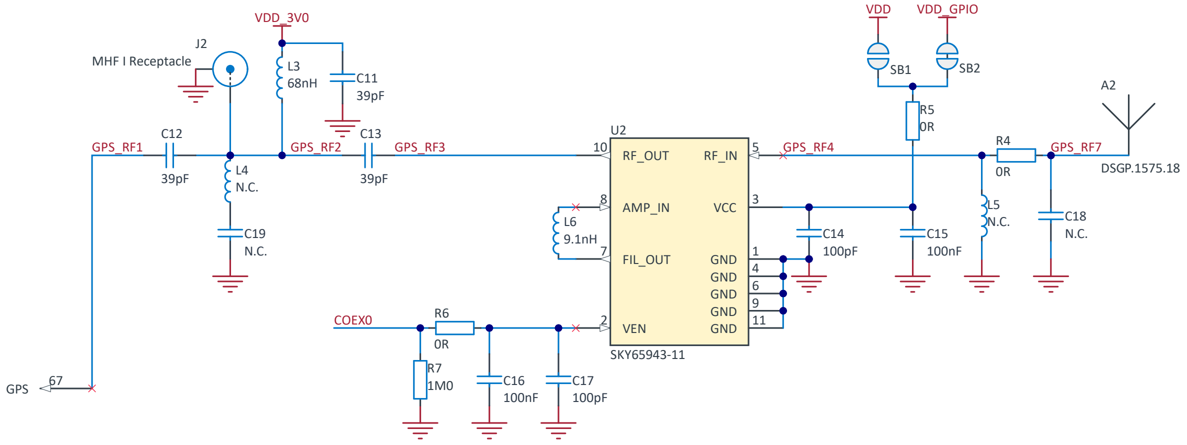


Figure 11: GNSS connected to the nRF9151

4.6 GPIO interfaces

Access to the nRF9151 *General-Purpose Input/Output (GPIO)*s is available from connectors **P2**, **P3**, **P4**, **P6**, and **P24**. The nRF9151 DK supports the Arduino UNO interface.

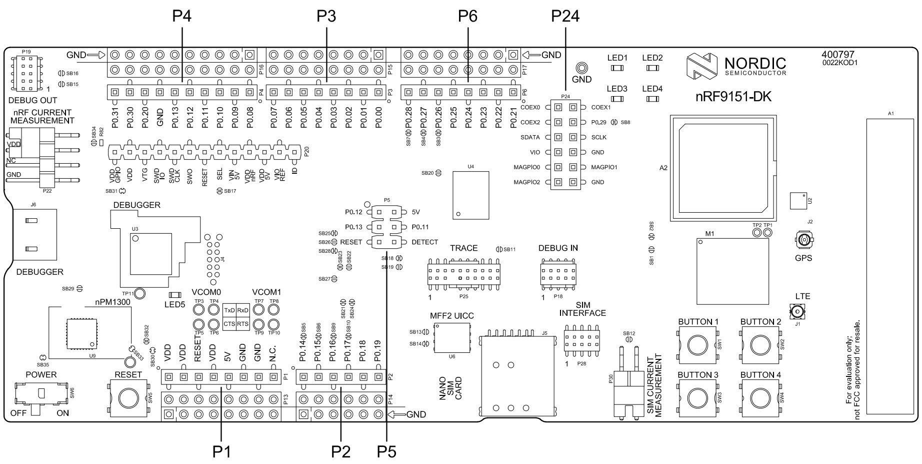


Figure 12: Access to GPIOs

GPIO signals are also available on connectors **P7, P8**, **P9**, **P10**, **P12**, and **P27** which are on the back of the *DK*. By mounting pin headers on the connector footprints, the nRF9151 DK can be used as a shield for Arduino motherboards.

For easy access to GPIO, power, and ground, the signals can also be found on the through-hole connectors **P14**, **P15**, **P16**, and **P17**.

4.7 Board control

The interface MCU contains a board controller that controls the signals which enable and disable features on the nRF9151 DK.

All features on the nRF9151 DK have a default setting that is applied at the first boot. The configuration of the board controller can be changed through nRF Connect for Desktop's Board Configurator application. For more information, see nRF Connect Board Configurator.

The configurable features and their default states are shown in the following table.

Feature	Configuration	State	Default state	IMCU pin	Description
VCOM 0	True	Disconnected	Connected	`P1.10`	Connect or disconnect the pins for the virtual COM port. When disconnected, the UART0 *GPIO* pins can be used for other purposes.
	False	Connected			
VCOM0 HWFC	True	Disconnected	Connected	`P0.20`	Connect or disconnect the *HWFC* pins for the virtual COM port. When disconnected, the HWFC GPIO pins for the target chip can be used for other purposes. When connected, an auto-detect feature is used to determine whether HWFC is enabled on the target chip.
	False	Connected			
VCOM 1	True	Disconnected	Connected	`P0.22`	Connect or disconnect the pins for the virtual COM port. When disconnected, the UART1 GPIO pins can be used for other purposes.
	False	Connected			
VCOM1 HWFC	True	Disconnected	Connected	`P0.23`	Connect or disconnect the HWFC pins for the virtual COM port. When disconnected, the HWFC GPIO pins for the target chip can be used for other purposes. When connected, an auto-detect feature is used to determine whether HWFC is enabled on the target chip.
	False	Connected			
SWD control	True	Disabled	Enabled	`P0.06`	Enable or disable the *SWD* connection between the IMCU and target chip. This allows the use of an external debugger.
	False	Enabled			
Shield reset in	True	Enabled	Disabled	`P0.07`	Enable or disable the reset line coming from a connected DK shield.
	False	Disabled			
Shield reset out	True	Enabled	Disabled	`P0.08`	Enable or disable the reset line going to a connected DK shield.
	False	Disabled			
SIM select	True	*SIM* card	SIM card	`P0.14`	Select whether SIM card or *Embedded SIM (eSIM)* is used.
	False	E-sim			
Modem coexistence interface	True	Disabled	Disabled	`P0.18`	Enable or disable the GPIO pin connection to the coexistence interface. This
	False	Enabled			

Feature	Configuration	State	Default state	IMCU pin	Description
					allows the GPIO pins to be used for other use cases.
I/O expander	True	Enabled	Disabled	**P1.13**	Enable or disable the I/O expander module that can control the LEDs and buttons on the DK using an other interface than the GPIOs if the pins are needed for other use cases.
	False	Disabled			
External memory	True	Disabled	Enabled	**P1.15**	Enable or disable the external memory chip.
	False	Enabled			

Table 1: Configurable features on the nRF9151 DK

4.8 Buttons and LEDs

The nRF9151 DK has four LEDs and four buttons for user interaction. By default, they are connected to the nRF9151 *GPIO*s as shown in the following table.

Part	GPIO
LED 1	P0.00
LED 2	P0.01
LED 3	P0.04
LED 4	P0.05
Button 1	P0.08
Button 2	P0.09
Button 3	P0.18/AIN5
Button 4	P0.19/AIN6

Table 2: Button and LED connection

To change default nRF9151 GPIO connections, see Board control on page 14.

Any LED or button can optionally be routed to an I/O expander. For more information, see I/O expander on page 18.

The buttons are active low, meaning that the input is connected to ground when the buttons are pushed. They have no external pull-up resistor, and therefore the **P0.08**, **P0.09**, **P0.18**, and **P0.19** pins must be configured as an input with an internal pull-up resistor.

The LEDs are active high, meaning that writing a logical one (`1`) to the output pin illuminates the LED. The nRF9151 GPIOs control power transistors, and the LEDs are fed from a separate 3.0 V domain. Therefore, LED current is not drawn from nRF9151 GPIOs or the nRF9151 supply.

The following figures show the buttons and LEDs.

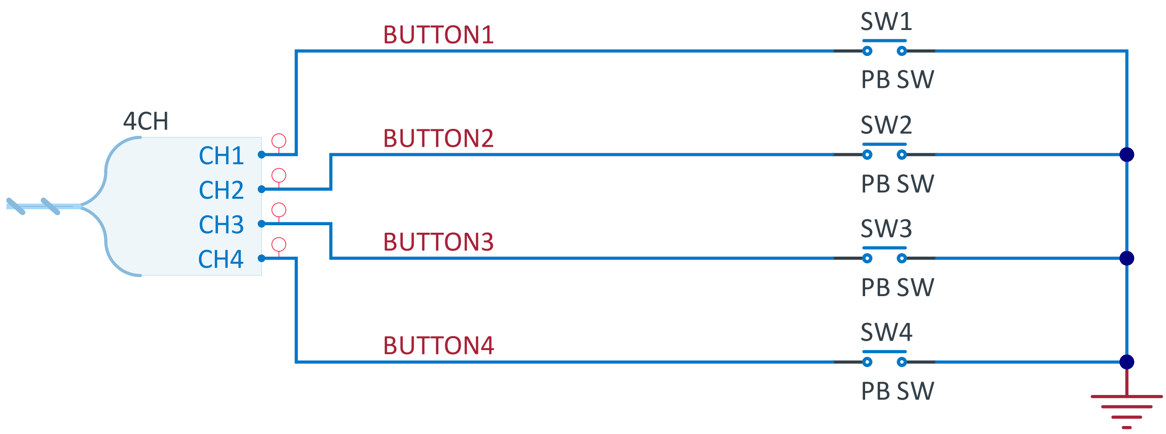


Figure 13: Buttons

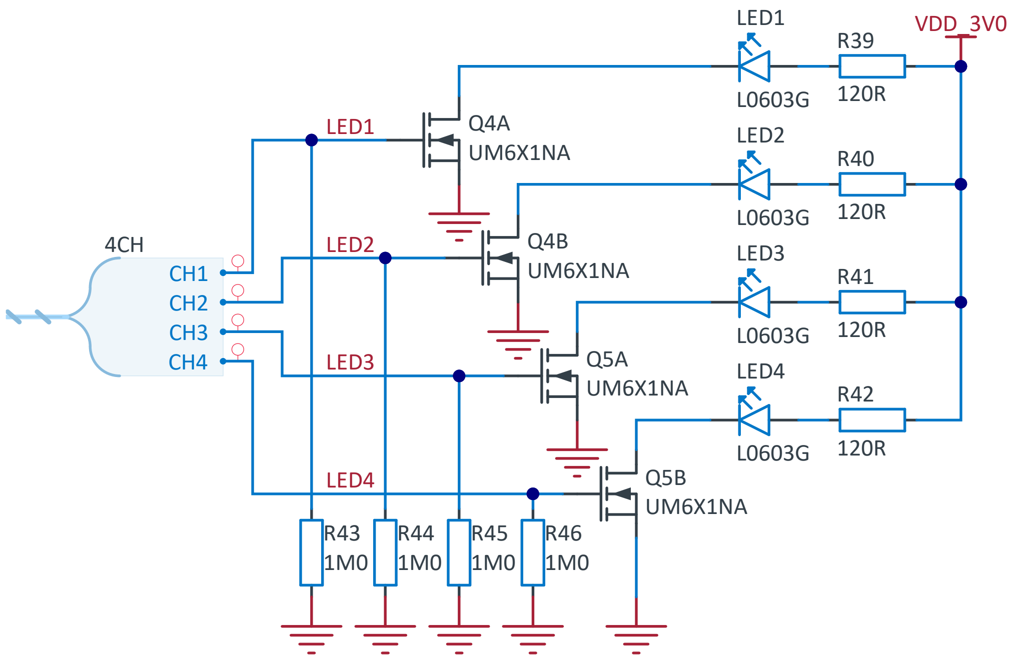


Figure 14: LEDs

4.8.1 I/O expander

The nRF9151 DK has an I/O expander that can optionally be used to interface the LEDs and buttons.

Signal	GPIO	Description
SDA	P0.30	I2C data line
SCL	P0.31	I2C clock line
IOEXP_IRQ	P0.19	Interrupt line from the I/O expander

Table 3: I/O expander interface

The following table shows the I/O expander connections.

Component	I/O expander pin
LED 1	I/O_EXP_IO4
LED 2	I/O_EXP_IO5
LED 3	I/O_EXP_IO6
LED 4	I/O_EXP_IO7
Button 1	I/O_EXP_IO0
Button 2	I/O_EXP_IO1
Button 3	I/O_EXP_IO2
Button 4	I/O_EXP_IO3

Table 4: I/O expander connections

The following figure shows the I/O expander connections.

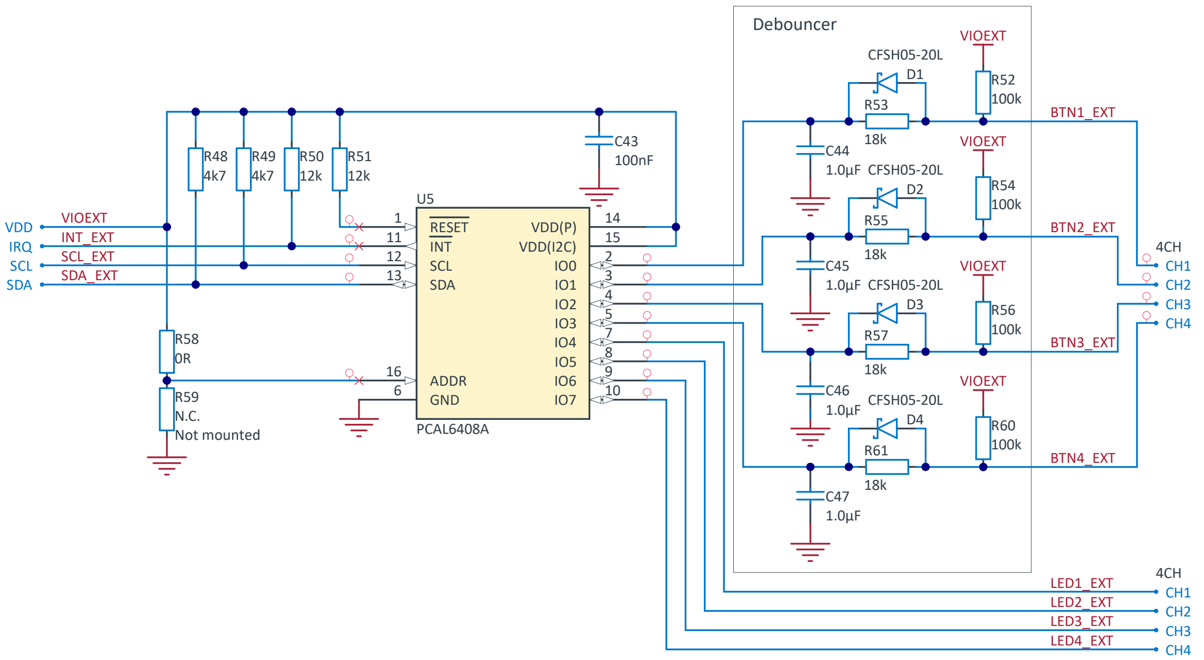


Figure 15: I/O expander

4.9 External memory

The nRF9151 DK has a 256 Mb (32 MB) external flash memory.

The memory is connected to the IC using the following GPIOs.

GPIO	Flash memory pin
P0.20	CS
P0.13	SCLK
P0.11	MOSI
P0.12	MISO

Table 5: Flash memory GPIO usage

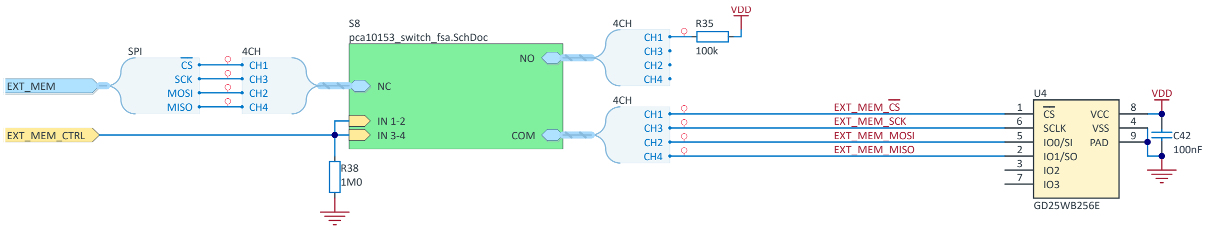


Figure 16: Flash memory

4.10 Debug input and trace options

The primary debug interface on the nRF9151 DK is the Segger OB debugger available through the *USB* port. If a power supply other than USB is used on the *DK*, this functionality is disabled.

The Debug in connector **P18** makes it possible to connect external debuggers for debugging when the interface USB cable is not connected or if the DK is in IF MCU DISCONNECT mode.

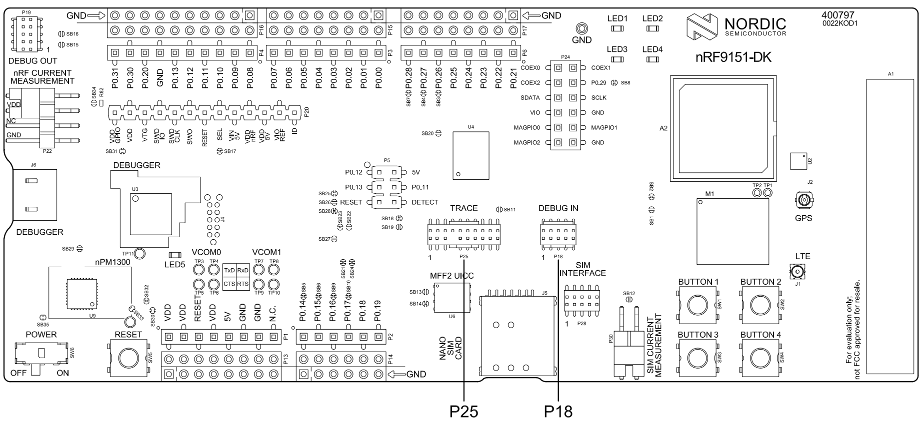


Figure 17: Debug input and trace connectors

To utilize the software trace feature on nRF9151, a 20-pin connector (**P25**) is available. nRF9151 *GPIO*s used for the trace interface are not available for application firmware use during trace.

GPIO	Trace
P0.21	TRACECLK
P0.22	TRACEDATA[0]
P0.23	TRACEDATA[1]
P0.24	TRACEDATA[2]
P0.25	TRACEDATA[3]

Table 6: Trace interfaces

4.11 Debug out for programming external boards

The nRF9151 DK supports programming and debugging external boards with nRF51 Series, nRF52 Series, nRF53 Series, and nRF70 Series *System on Chip (SoC)*s and nRF91 Series *SiP*s.

The interface MCU on the nRF9151 DK runs SEGGER J-Link OB Debugger interface firmware and is used to program and debug the firmware of the nRF9151 *SiP* by default.

To program or debug an external board, connect to the Debug out connector (**P19**) using a 10-pin cable or use **P20** for custom connection.

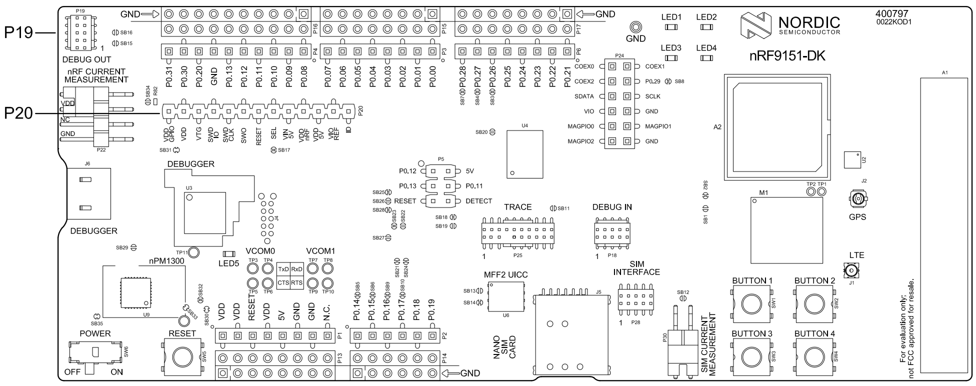


Figure 18: Debug output connectors

4.11.1 Programming an external board

For boards with a standard 10-pin *SWD* connector or a connector that supports a standard 10-pin flat cable, connection to **P19** is recommended.

Connect the boards as shown in the following figure.

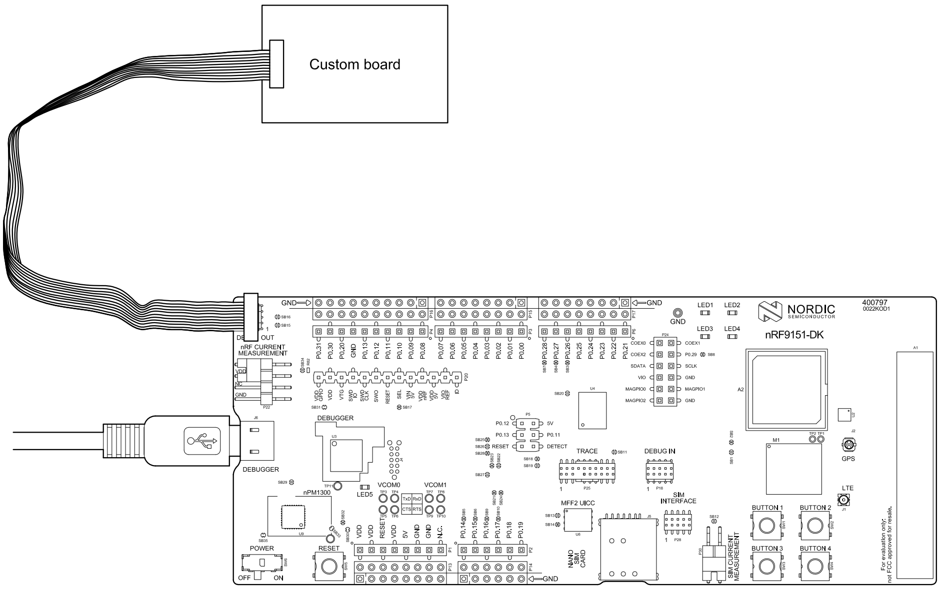


Figure 19: Connecting an external board to P19

It is recommended to power the external board separately from the DK. The voltage of the SWD interface on the external board must match that of the DK. The default voltage is 1.8 V.

When the interface MCU detects GND of the external board on **pin 3** (**`SELECT`**) of **P19**, it programs or debugs the target chip on the external board instead of the onboard nRF9151 *SiP*.

The following figure and table show the **P19** pinout.

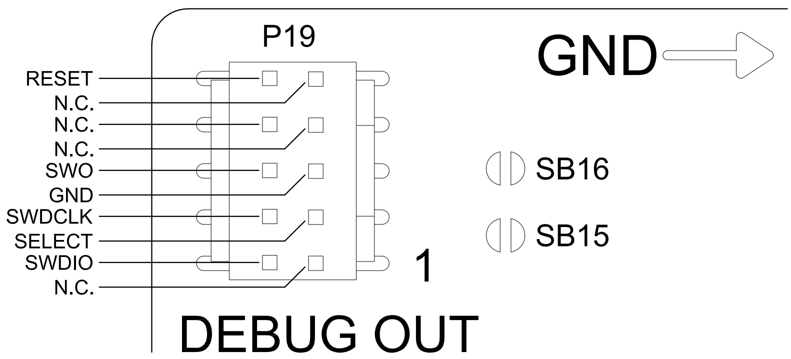


Figure 20: Debug output connector P19

Pin number	Signal	Description
1	EXT_VDD	By default not connected, for configuration see **SB15** and **SB16** in Solder bridge configuration on page 28
2	SWDIO	*SWD* data input/output
3	SELECT	Select pin for the interface MCU, should be connected to GND on the external board
4	SWDCLK	Serial wire clock line
5	GND	Ground
6	SWO	*Serial Wire Output (SWO)* line is not used for programming and debugging over SWD
7	N.C.	Not used
8	N.C.	Not used
9	N.C.	Not used
10	RESET	Reset line

Table 7: Pinout of connector P19 for programming external targets

If you do not have a separate power supply on the external board connected to the Debug out connector **P19**, the external board can be powered from the onboard DK regulator as follows:

1. Short solder bridge **SB16** to enable power output on **P19**.
2. Power the DK through the USB connector.

> **CAUTION:** To avoid damaging your board when **SB16** is shorted, do not connect a separate power supply to the external board and follow the instructions carefully.

4.11.2 Programming a board with custom connections

If your external board has custom connections for programming and debugging pins, you can use the debug output on **P20**.

Connect the boards as shown in the following figure.

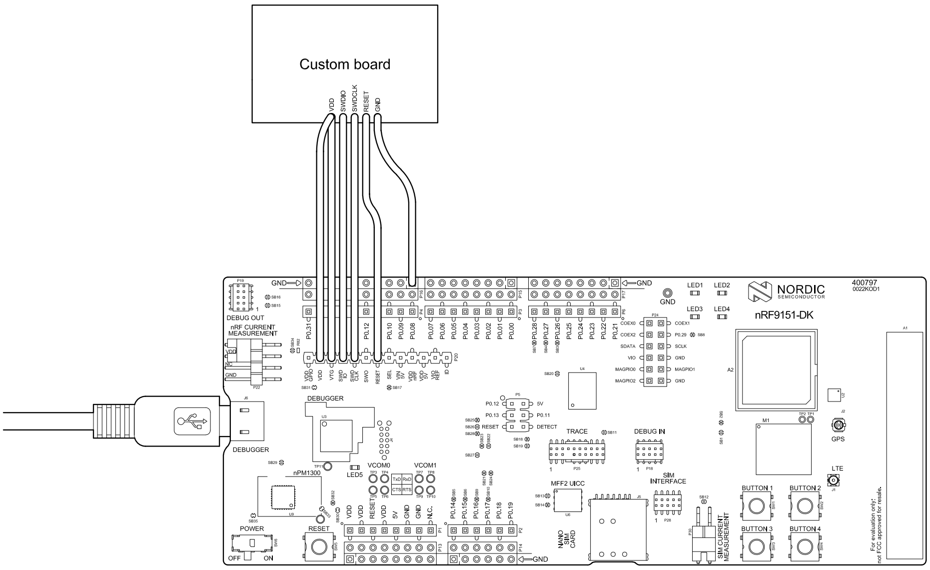


Figure 21: Connecting a custom board to P20

It is recommended to power the external board separately from the DK. The voltage of the SWD interface on the external board must match that of the DK. The default voltage is 1.8 V.

When the interface MCU detects the voltage of the external board on **pin 3** (**`VTG`**) or ground on **pin 8** (**`SEL`**) of **P20**, it programs or debugs the target chip on the external board instead of the onboard nRF9151 *SiP*.

> **Note:** If the interface MCU detects connection on **P19** and **P20**, it programs or debugs the target connected to **P19** by default.

If there is no separate power supply on the external board, the nRF9151 DK can supply power through pin 2 (**`VDD`**) of **P20**.

> **CAUTION:** To avoid damaging your board, when **`VDD`** of nRF9151 DK is connected to the external board, do not connect a separate power supply to the external board.

The following figure and table show the **P20** connector pinouts.

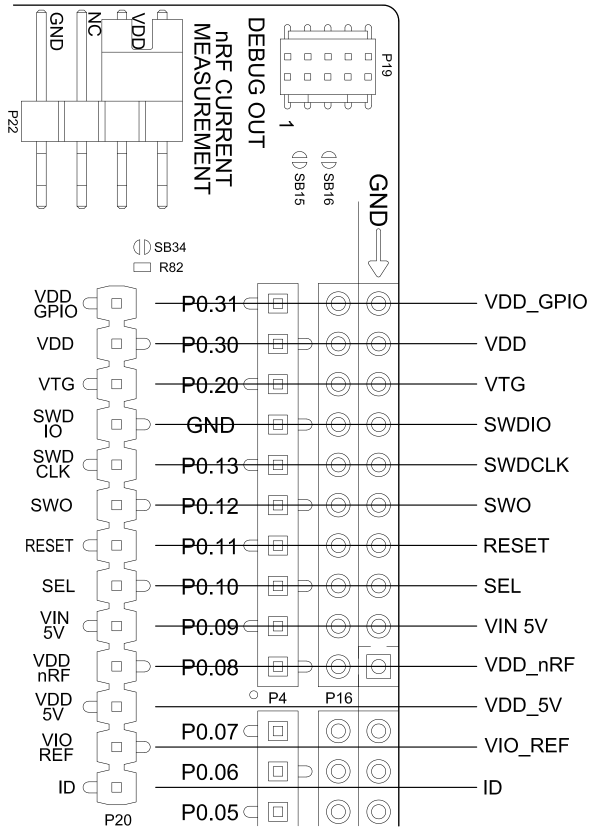


Figure 22: Debug output connector P20

Pin number	Signal	Description
1	VDD_GPIO	Supply for the nRF9151 *GPIO* pins
2	VDD	Main nRF9151 DK GPIO level power domain
3	VTG	Voltage supply from the external target, used as a select pin for the interface MCU to enable this port
4	SWDIO	*SWD* data line
5	SWDCLK	Serial wire clock line
6	SWO	The *SWO* line is not used for programming and debugging over SWD
7	RESET	Reset line
8	SEL	Ground detect, used as a select pin for the interface MCU to enable this port
9	VIN 5V	Voltage supply
10	VDD_nRF	nRF9151 SiP power domain
11	VDD_5V	Main nRF9151 DK 5V level power domain
12	VIO_REF	GPIO voltage reference input
13	ID	ID resistor to ground

Table 8: Pinout of connector P20 for programming external targets

4.12 Signal routing switches

Several of the *GPIO* signals of the nRF9151 DK are routed through analog switches for onboard functionality or for having them available on the pin headers for external circuitry or Arduino-type shields.

4.12.1 Switches for UART interface

Two UART interfaces are routed between the interface MCU and the nRF9151 *SiP*. These can be controlled individually by the board controller.

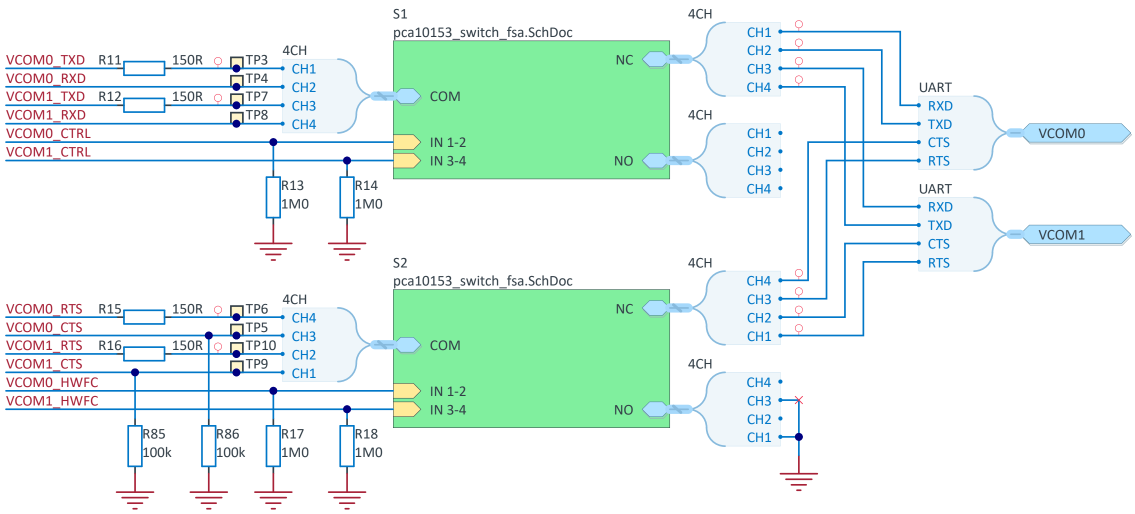


Figure 23: UART interface switches

4.12.2 Switches for buttons and LEDs

On the nRF9151 DK, there are analog switches that are used to connect and disconnect signals to control buttons, switches, and LEDs.

The analog switches control whether the LEDs, buttons, and switches are connected directly to the nRF9151 *GPIO* or to an I/O expander. The switches are controlled by the board controller *SoC*, which contains Nordic Semiconductor firmware. For more information, see I/O expander on page 18.

4.12.3 Switches for external memory

An analog switch allows the external memory to be disconnected from the *SiP*.

For more information, see Figure 16: Flash memory on page 20.

4.13 SIM and eSIM

The nRF9151 DK is designed to support regular *SIM* and *eSIM*. For this purpose, it has a pluggable SIM card socket (**J5**) that takes a nano-sized SIM (4FF) and a non-populated footprint for an eSIM (MFF2).

Using the SIM socket is the default. If an eSIM is soldered onto the *DK*, the board controller can be used to select the eSIM. Connector **P28** can be used to connect and monitor the traffic on the SIM interface.

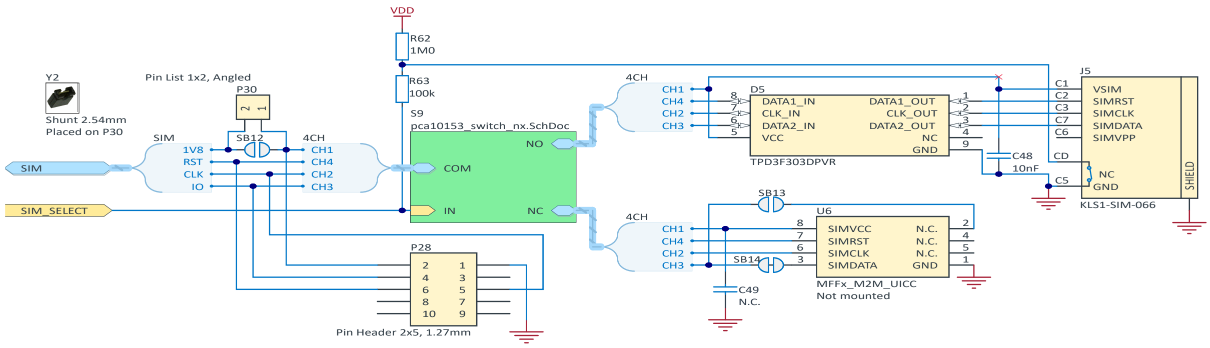


Figure 24: SIM card connector, eSIM, and selection switch

Note: The nano-SIM card is inserted with the electrical interface down in the SIM card holder (**J5**).

4.14 Additional interfaces

The nRF9151 DK supports dedicated interfaces for coexistence. They are exposed on connector P24.

Three COEX pins enable coexistence handling between multiple wireless devices. COEX0 is used to enable the *GNSS LNA* of the nRF9151 DK.

The nRF9151 DK has an interface allowing the modem to control external RF applications, such as antenna tuner devices. There are three MIPI RFFE interface pins, namely, VIO, SCLK, SDATA, and three MAGPIO interface pins, namely, MAGPIO0, MAGPIO1, and MAGPIO2.

Pin	Signal
1	COEX0
2	COEX1
3	COEX2
4	P0.29
5	MIPI_SDATA
6	MIPI_SCLK
7	MIPI_VIO
8	GND
9	MAGPIO0
10	MAGPIO1
11	MAGPIO2
12	GND

Table 9: Interfaces for coexistence on P24

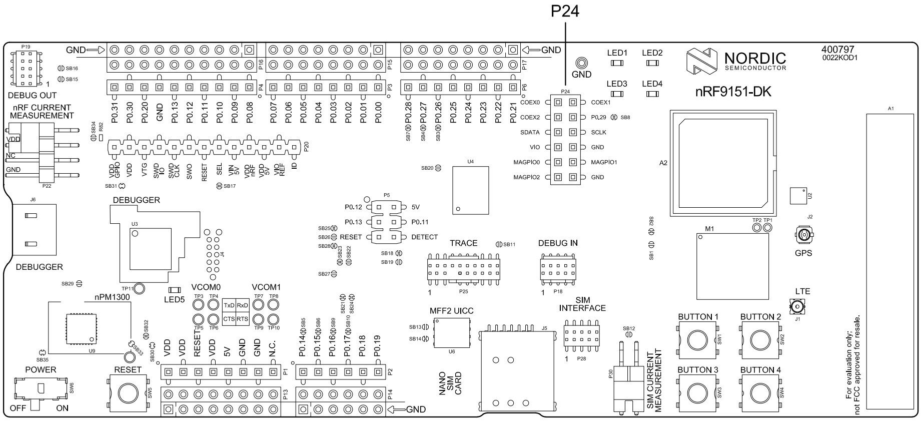


Figure 25: SiP-external interfaces

4.15 SiP enable

The nRF9151 *SiP* can be enabled by pulling pin **101** high or disabled by pulling pin **101** low. By default, the enable signal is pulled high by resistor **R1**.

4.16 Solder bridge configuration

The nRF9151 DK has a range of solder bridges for enabling or disabling functionality on the *DK*. Changes to these are not needed for normal use of the DK.

The following table is a complete overview of the solder bridges on the nRF9151 DK.

Solder bridge	Default	Function
SB1	Open	Short to power GNSS LNA from VDD domain. SB1 and SB2 should not be shorted at the same time.
SB2	Closed	Cut to disconnect VDD_GPIO supply from GNSS LNA. SB2 and SB1 should not be shorted at the same time.
SB3	Closed	Cut to disconnect RXD of UART1 from nRF9151 SiP
SB4	Closed	Cut to disconnect TXD of UART1 from nRF9151 SiP
SB5	Closed	Cut to disconnect RTS of UART1 from nRF9151 SiP
SB6	Closed	Cut to disconnect CTS of UART1 from nRF9151 SiP
SB7	Closed	Cut to disconnect RXD of UART2 from nRF9151 SiP
SB8	Closed	Cut to disconnect TXD of UART2 from nRF9151 SiP
SB9	Closed	Cut to disconnect RTS of UART2 from nRF9151 SiP
SB10	Closed	Cut to disconnect CTS of UART2 from nRF9151 SiP
SB12	Open	Short to permanently connect SIM VDD, bypass SIM current measurement connector
SB13	Open	Close to reroute SIMDATA to pin 2 of MFF2
SB14	Closed	Cut to disconnect SIMDATA from pin 3 of MFF2

Solder bridge	Default	Function
SB15	Open	Short to connect external board power to VIO_REF
SB16	Open	Short to use VDD rail as power source for the external board
SB17	Closed	Cut to disable **P20** pin 3 (**`VTG`**) as select pin
SB18	Closed	Cut to disconnect **P5** pin 6 from shield detect
SB19	Open	Short to connect **P5** pin 6 to GND
SB20	Open	Close to connect VDD to the UART1 connector
SB21	Closed	Cut to disconnect RESET from **P7**
SB22	Open	Short to connect **`P0.21`** to RESET on **P1**
SB23	Closed	Cut to disconnect **`P0.21`** from RESET on **P7**
SB24	Closed	Cut to disconnect RESET from AREF on **P4** and **P10**
SB25	Closed	Cut to disconnect RESET pins of **P11** and **P7**
SB26	Open	Short to connect RESET pins of **P11** and **P5**
SB27	Open	Short to connect RESET pins of **P1** and **P7**
SB28	Closed	Cut to disconnect RESET pins of **P1** and **P5**
SB29	Open	Short to permanently enable USB_DETECT signal
SB30	Closed	Cut to disconnect VIO supply to **P1** and **P7**
SB31	Closed	Cut to enable nRF9151 VDD_GPIO current measurement on **P20**
SB32	Closed	Cut to disconnect interface MCU power supply
SB33	Closed	Cut to disconnect nPM1300 output from VDD
SB34	Open	Short to permanently connect VDD_nRF and VDD_nRF', bypass current measurement connector
SB35	Closed	Cut to disconnect 5V on **P1** and **P7** from VDD_5V

Table 10: Solder bridge configuration

5 Current measurement

The current drawn by the nRF9151 *SiP* can be monitored on the nRF9151 *DK*.

Current can be measured using any of the following test instruments:

- Power analyzer
- Oscilloscope
- Ampere meter
- Power Profiler Kit II

Power analyzer measurements are not described in this document. For more information on the other instruments, see the following sections and Power Profiler Kit II User Guide.

You can use connector **P22** for measuring current consumption or monitoring voltage levels on the nRF9151 DK. For more information, see Prepare the DK for current measurements on page 30.

The use of a USB connector is not recommended for powering the *DK* during current measurements due to potential noise from the USB power supply. Instead, the DK should be powered externally through the **`VIN 5V`** pin on connector **P20**.

For more information on measuring, see Measure current profile with an oscilloscope on page 31 and Measure average current with an ampere meter on page 32.

5.1 Prepare the DK for current measurements

To measure the current consumption of the *SiP*, you must first remove the jumper from **P22**.

Removing the jumper disconnects the nRF9151 SiP from the DK's power supply.

To restore normal kit functionality after measurement, apply the jumper on **P22** or short **SB34**.

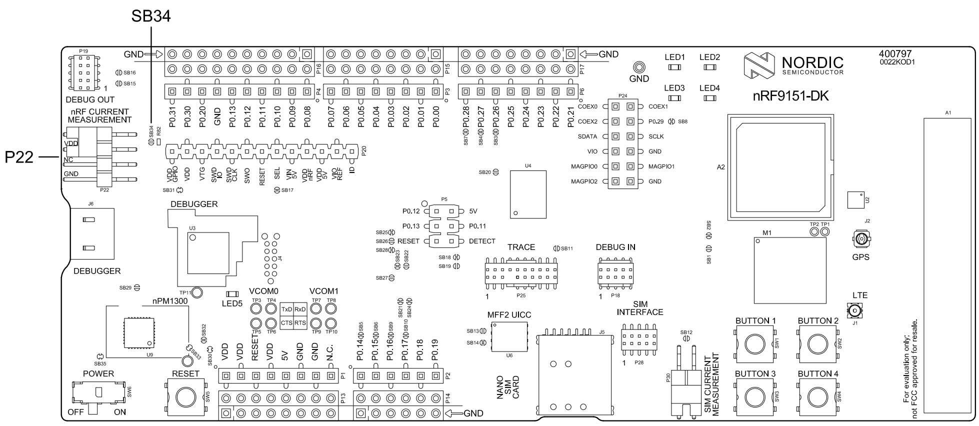


Figure 26: Solder bridge SB34 and P22 on the nRF9151 DK

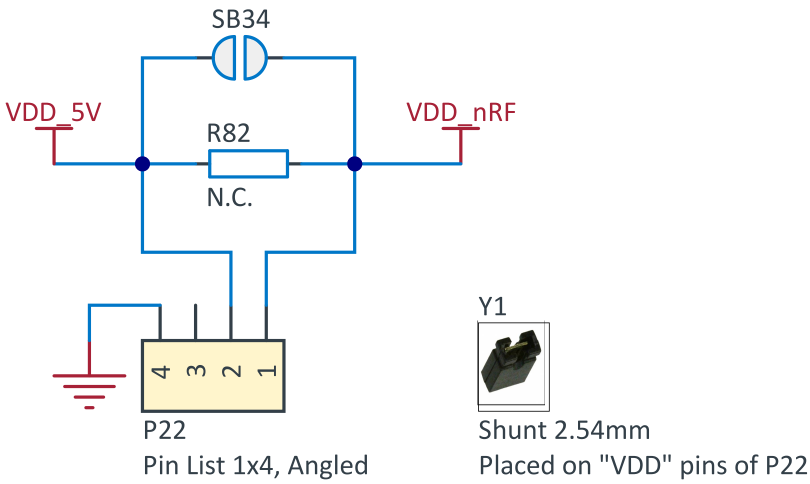


Figure 27: nRF power source select

5.2 Measure current profile with an oscilloscope

An oscilloscope can be used to measure the current over a given or continuous time interval and to capture the current profile.

Before you start, make sure you have prepared the *DK* as described in Prepare the DK for current measurements on page 30.

Complete the following steps to measure the current profile of the nRF9151 DK:

1. Solder a 0.5 Ω resistor to **R82**.
2. Set the oscilloscope to differential mode or to a mode that is similar.
3. Connect the oscilloscope using two probes on the pins of the **P22** connector.
4. Calculate or plot the instantaneous current from the voltage drop across the 0.5 Ω resistor by taking the difference of the voltages measured on the two probes.

   The voltage drop is proportional to the current.
5. Measure the voltage drop over the 0.5 Ω resistor to get the current power profile.

   The plotted voltage drop can be used to calculate the current at a given point in time. The current can then be averaged or integrated to analyze current and energy consumption over a period.

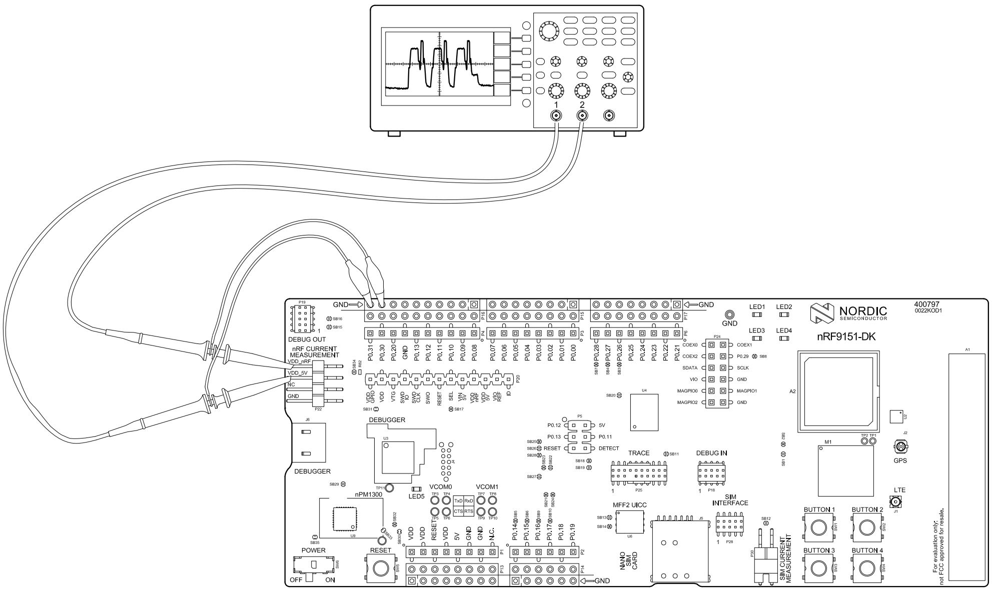


Figure 28: Current measurement with an oscilloscope

To reduce noise, do the following:

- Use probes with 1x attenuation.
- Enable averaging mode to reduce random noise.
- Enable high resolution function if available.

A minimum of one sample every 5 µs is needed to accurately measure the average current.

5.3 Measure average current with an ampere meter

The current drawn by the nRF9151 *SiP* can be measured using an ampere meter.

Before you start, make sure you have prepared the *DK* as described in Prepare the DK for current measurements on page 30.

Complete the following steps to measure the average current drawn by the nRF9151 SiP:

1. Set the average timing of the ampere meter to a long interval, such as 1 s or longer.
2. Set the dynamic range of the ampere meter between 1 µA and 15 mA so that it is wide enough to provide accurate measurements.
3. To connect the ampere meter in series with the nRF9151 SiP, connect the ampere meter to the pins on connector **P22**.

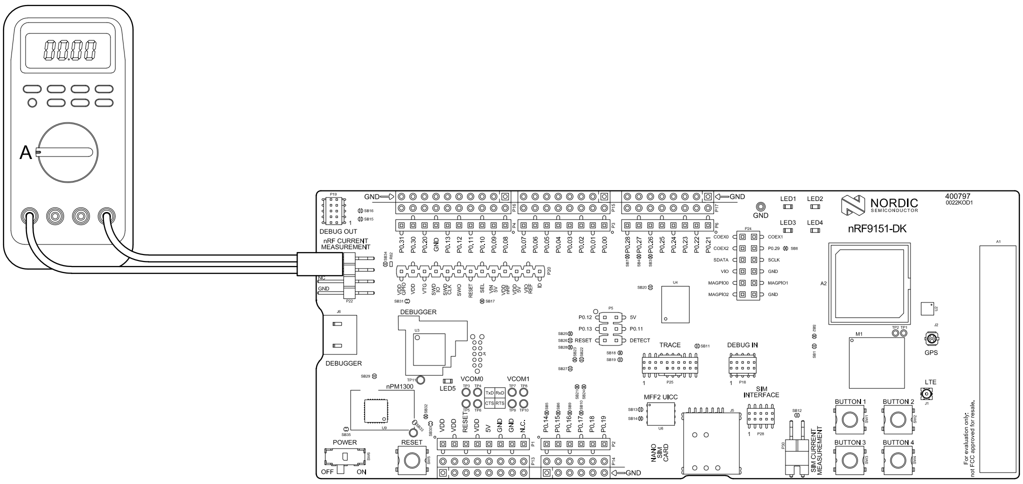


Figure 29: Current measurement with an ampere meter

> **Note:** Use a high-speed, high-dynamic-range ampere meter for the best and most reliable measurements. Switching the current range in the ampere meter can affect the power supply to the nRF9151 DK. High speed and bandwidth are required to detect rapid changes in the current consumption in the nRF9151 DK.

6 RF measurements

The nRF9151 DK is equipped with a small coaxial connector **J1** for measuring the LTE or *DECT NR+* RF signal.

The connector is of *Microwave coaxial connector with switch (SWF)* type (Murata part no. MM8130-2600) with an internal switch. By default, when no cable is attached, the RF signal is routed to the onboard antenna. The insertion loss in the adapter cable is approximately 0.5 dB–1 dB.

An adapter (Murata part no. MXHS83QE3000) is available with a standard SMA connection on the other end for connecting instruments (the adapter is not included in the kit). When connecting the adapter, the internal switch in the SWF connector disconnects the onboard antenna and connects the RF signal from nRF9151 to the adapter.

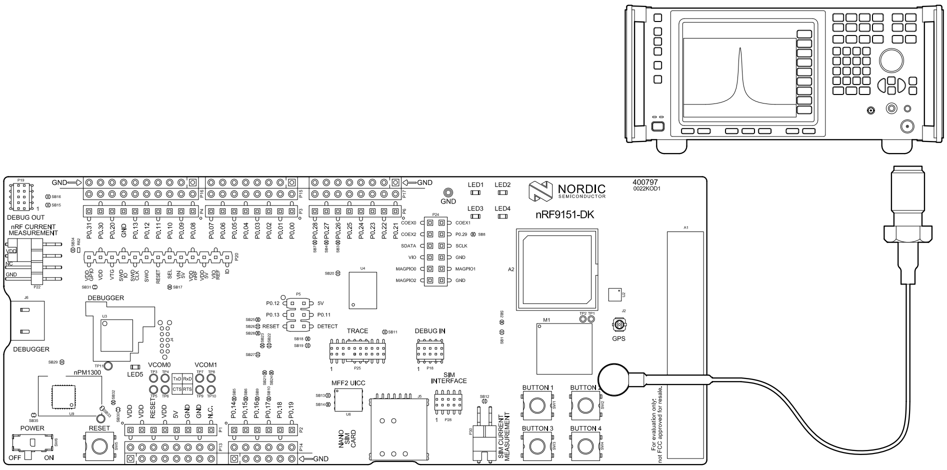


Figure 30: Connecting a spectrum analyzer

7 Radiated performance

The *LTE* antenna on the *DK* is optimized for global operation, supporting all LTE frequency bands in the region of 698 MHz to 960 MHz and 1710 MHz to 2200 MHz.

All antennas on the nRF9151 DK have fixed matching networks, which means that a matching configuration is not needed to switch between the frequency bands. The LTE antenna also supports other frequency ranges, but it is not optimized for operating on these frequency bands.

8 Regulatory information

The nRF9151 *DK* contains an nRF9151 *SiP* which is FCC certified.

For information on the bands supported by the nRF9151 *SiP* and for FCC regulatory notices, see Regulatory information in the nRF9151 Product Specification.

This DK is designed to allow the following:

- Product developers to evaluate electronic components, circuitry, or software associated with the DK to determine whether to incorporate such items in a finished product
- Software developers to write software applications for use with the end product

This DK is not a finished product and when assembled cannot be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this DK not cause harmful interference to licensed radio stations and that this DK accept harmful interference. Unless the assembled DK is designed to operate under 47 CFR Part 15, 47 CFR Part 18, and 47 CFR Part 95, the operator of the DK must operate under the authority of an FCC license holder or must secure an experimental authorization under 47 CFR Part 5.

For information on the supported frequency bands of the LTE antenna on the DK, see Radiated performance on page 35.

Glossary

AT command
: A command used to control the modem.

Band-Pass Filter (BPF)
: An electronic device or circuit that passes frequencies within a certain range and rejects frequencies outside that range.

Cat-M1
: LTE-M User Equipment (UE) category with a single RX antenna, specified in 3GPP Release 13.

Cat-NB1
: NB-IoT User Equipment (UE) category with 200 kHz UE bandwidth and a single RX antenna, specified in 3GPP Release 13.

Cat-NB2
: An upgraded version of Cat-NB1, specified in 3GPP Release 14.

Clear to Send (CTS)
: In flow control, the receiving end is ready and telling the far end to start sending.

DECT NR+
: A non-cellular radio standard included as part of the 5G standards by the ITU.

DC
: Direct Current

Development Kit (DK)
: A hardware development platform used for application development.

Electrostatic Discharge (ESD)
: A sudden discharge of electric current between two electrically charged objects.

Embedded SIM (eSIM)
: A form of programmable *SIM* that is embedded directly into a device.

Fast Identity Online (FIDO)
: A bundle of hardware and software modules serving as a tracing interface between traced device(s) and user application.

Global Navigation Satellite System (GNSS)
: A satellite navigation system with global coverage. The system provides signals from space transmitting positioning and timing data to GNSS receivers, which use this data to determine location.

General-Purpose Input/Output (GPIO)

A digital signal pin that can be used as input, output, or both. It is uncommitted and can be controlled by the user at runtime.

Global Positioning System (GPS)

A satellite-based radio navigation system that provides its users with accurate location and time information over the globe.

Hardware Flow Control (HWFC)

A handshaking mechanism used to prevent an overflow of bytes in modems. It uses two dedicated pins on the RS-232 connector, Request to Send and Clear to Send.

Integrated Circuit (IC)

A semiconductor chip consisting of fabricated transistors, resistors, and capacitors.

Inter-integrated Circuit (I^2C)

A multi-master, multi-slave, packet-switched, single-ended, serial computer bus.

Low-Dropout Regulator (LDO)

A linear voltage regulator that can operate even when the supply voltage is very close to the desired output voltage.

Low-Noise Amplifier (LNA)

In a radio receiving system, an electronic amplifier that amplifies a very low-power signal without significantly degrading its signal-to-noise ratio.

Low-Power Wide Area (LPWA)

A wireless communication technology designed to allow long-range communication at a low bit rate.

Long-Term Evolution (LTE)

A wireless broadband communication standard for mobile devices and data terminals, based on the GSM/EDGE and UMTS/HSPA technologies.

LTE-M

An open standard that is most suitable for medium throughput applications requiring low power, low latency, and/or mobility, like asset tracking, wearables, medical, POS, and home security applications. Also known as Cat-M1.

Mass Storage Device (MSD)

Any storage device that makes it possible to store and port large amounts of data in a permanent and machine-readable fashion.

nRF Cloud

Nordic Semiconductor's platform for connecting IoT devices to the cloud, viewing and analyzing device message data, prototyping ideas that use Nordic Semiconductor chips, and more. It includes a public REST API that can be used for building IoT solutions. See nRF Cloud portal (nrfcloud.com).

Operational Amplifier (op-amp)

A high-gain voltage amplifier that has a differential input and, usually, a single output.

Receive Data (RXD)

A signal line in a serial interface that receives data from another device.

Request to Send (RTS)

In flow control, the transmitting end is ready and requesting the far end for a permission to transfer data.

SAW filter

A high-performing filter using Surface Acoustic Wave (SAW) technology. This technology employs piezoelectric transducers, which, when excited, produce waves that are used to filter out desired frequencies.

Serial Wire Debug (SWD)

A standard two-wire interface for programming and debugging Arm® CPUs.

Subscriber Identity Module (SIM)

A card used in User Equipment (UE) containing data for subscriber identification.

Surface Acoustic Wave (SAW)

An acoustic wave traveling along the surface of a material exhibiting elasticity, with an amplitude that typically decays exponentially with depth into the substrate.

Subscriber Identity Module (SIM)

A card used in User Equipment (UE) containing data for subscriber identification.

System in Package (SiP)

Several integrated circuits, often from different technologies, enclosed in a single module that performs as a system or subsystem.

System on Chip (SoC)

A microchip that integrates all the necessary electronic circuits and components of a computer or other electronic systems on a single integrated circuit.

Microwave coaxial connector with switch (SWF)

A small, RF surface-mount switch connector series for wireless applications.

Serial Wire Output (SWO)

A data line for tracing and logging.

Transmit Data (TXD)

A signal line in a serial interface that transmits data to another device.

Universal Asynchronous Receiver/Transmitter (UART)

A hardware device for asynchronous serial communication between devices.

Universal Integrated Circuit Card (UICC)

A new generation Subscriber Identity Module (SIM) used in User Equipment (UE) for ensuring the integrity and security of personal data.

User Equipment (UE)

Any device used by an end-user to communicate. The UE consists of the Mobile Equipment (ME) and the Universal Integrated Circuit Card (UICC).

U.FL

An ultra-small surface-mount coaxial connector designed for high-frequency performance.

Universal Serial Bus (USB)

An industry standard that establishes specifications for cables and connectors and protocols for connection, communication, and power supply between computers, peripheral devices, and other computers.

Recommended reading

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

Nordic documentation

- nRF9151 Product Specification
- nRF Connect SDK documentation
- nRF91x1 Cellular AT Commands
- nRF Connect Programmer

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