

nRF9160 DK Hardware

User Guide

v0.9.3

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Revision history

Date	Version	Description
July 2020	0.9.3	Updated document title
April 2020	0.9.2	Editorial changes
March 2020	0.9.1	<ul style="list-style-type: none">• Updated Related documentation on page 7• Updated Debug output on page 25• Added Connectors for programming external boards on page 26
October 2019	0.9	Updated to match nRF9160 DK v0.9.0 <ul style="list-style-type: none">• Updated:<ul style="list-style-type: none">• Hardware content on page 8• Related documentation on page 7• Firmware development mode on page 9• Performance measurement mode on page 11• Block diagram on page 13• Hardware figures on page 13• Power supply on page 14• Antenna interfaces on page 17• GPS on page 17• nRF9160 DK board control on page 21• SIM and eSIM on page 32• Additional interfaces on page 33• Solder bridge configuration on page 34• Preparing the development kit for current measurements on page 36• New:<ul style="list-style-type: none">• Interface MCU disconnect switches on page 27• Switches for UART interface on page 28• Switches for nRF52840 interface on page 31• Removed:<ul style="list-style-type: none">• Getting started
July 2019	0.7.2	Updated: <ul style="list-style-type: none">• nRF9160 supply on page 16
March 2019	0.7.1	Updated to match nRF9160 DK v0.8.5: <ul style="list-style-type: none">• Hardware content on page 8• nRF9160 supply on page 16• Antenna interfaces on page 17• GPS on page 17• nRF9160 DK board control on page 21• Solder bridge configuration on page 34

Date	Version	Description
		<ul style="list-style-type: none">• Preparing the development kit for current measurements on page 36• RF measurements on page 39• Radiated performance of nRF9160 DK on page 40
December 2018	0.7	Updated to match nRF9160 DK v0.8.2
November 2018	0.5.1	Preview DK changed into DK
October 2018	0.5	First release

Previous versions

PDF files for the previous versions are available here:

- [nRF9160 DK User Guide v0.9](#)
- [nRF9160 DK User Guide v0.7.2](#)
- [nRF9160 DK User Guide v0.7.1](#)
- [nRF9160 DK User Guide v0.7](#)

1 Introduction

The nRF9160 DK is a hardware development platform used to design and develop application firmware on the nRF9160 LTE *Cat-M1* and *Cat-NB1 System in Package (SiP)*.

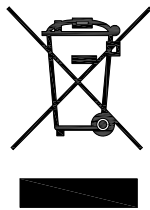
The *Development Kit (DK)* includes all necessary external circuitry like a SIM card holder and an antenna and it provides developers access to all I/O pins and relevant module interfaces.

Note: The *DK* can be connected to a base station by the onboard LTE antenna or to an LTE emulator by an RF cable. See our [nRF9160 certifications](#) webpage to find the bands supported by the LTE modem. Without a UICC/SIM connected, the *DK* cannot initiate communication with the LTE network.

The key features of the *DK* are:

- nRF9160 *SiP*
- LTE antenna that supports all bands supported by the *SiP*
- *Global Positioning System (GPS)* antenna
- nRF52840 as a board controller and network processor for *Bluetooth*[®] and IEEE 802.15.4 protocols
- Buttons, switches, and LEDs for user interaction
- I/O interface for Arduino form factor plug-in modules
- SEGGER J-Link OB Debugger with debug out functionality
- UART interface through virtual COM port
- USB connection for debug/programming and power
- SIM card socket for nano-SIM (4FF SIM)
- Interfaces for nRF9160 current consumption measurements

Note: nRF9160 DK is compliant with the PS1 classification according to the IEC 62368-1 standard.



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.

Skilled person: Person with relevant education or experience to enable him or her to identify hazards and to take appropriate actions to reduce the risks of injury to themselves and others.



2 Related documentation

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

Nordic documentation

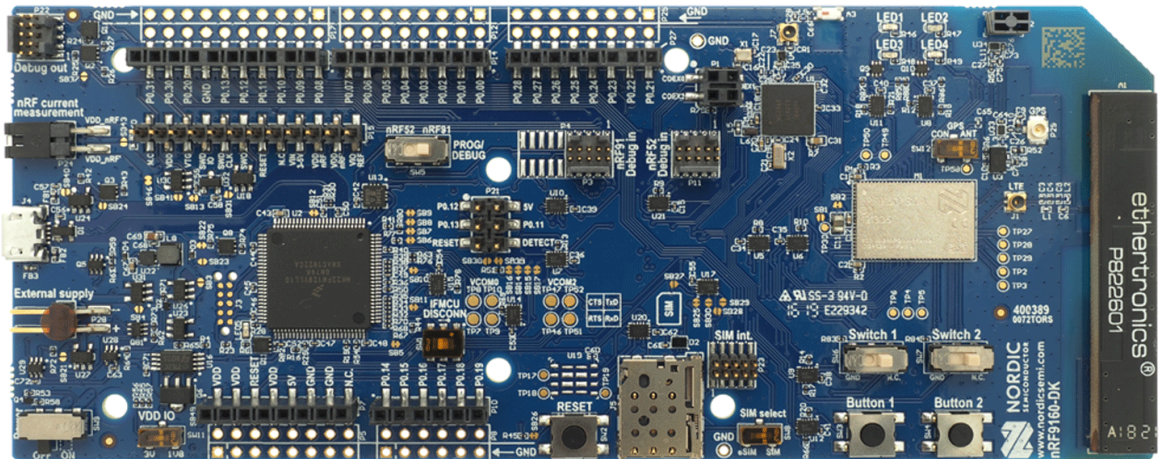
- [nRF9160 DK Getting Started Guide](#)
- [nRF9160 Product Specification](#)
- [nRF9160 Modem Firmware Release Notes \(included in the latest nRF9160 modem firmware\)](#)
- [nRF Connect SDK documentation](#)
- [nRF91 AT Commands Reference Guide](#)
- [nRF Connect Programmer](#)

3 Kit content

The nRF9160 DK includes hardware, preprogrammed firmware, documentation, hardware schematics, and layout files.

3.1 Hardware content

The nRF9160 DK v0.9.x (PCA10090) comes with a GPS antenna and a SIM card.



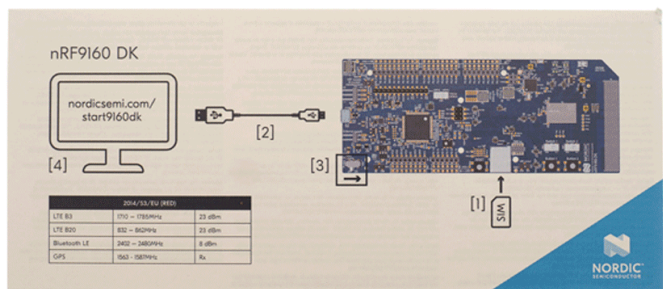
nRF9160 DK board (PCA10090)



SIM card



GPS antenna



Quick guide

Figure 1: nRF9160 DK v0.9.x kit content

Hardware files

The hardware design files including schematics, PCB layout files, bill of materials, and Gerber files for the nRF9160 DK are available on the product page, [nRF91 SIP Series](#).

The table below shows an overview of the GPIOs used for the UART connections on the nRF9160 and nRF52840:

	nRF91 APP1	nRF91 APP2	nRF52840
TXD	P0.29	P0.01	P0.03
RXD	P0.28	P0.00	P0.05
CTS	P0.26	P0.15	P0.07
RTS	P0.27	P0.14	P1.08

Table 1: GPIOs used for virtual COM ports on nRF9160 and nRF52840

Note:

- Baud rate 921 600 is not supported through the virtual COM port.

4.1.3 MSD

The interface MCU features a mass storage device (MSD). This makes the *DK* appear as an external drive on your computer.

This drive can be used for drag-and-drop programming. However, files cannot be stored on this drive. By copying a HEX file to the drive, the interface MCU will program the file to the device. The J-Link OB will program the target that is selected with the nRF52/nRF91 switch (**SW5**). For limitations on nRF52840 use, see [nRF9160 DK board control](#) on page 21.

Note:

- Windows might try to defragment the MSD part of the interface MCU. If this happens, the interface MCU will disconnect and become unresponsive. To return to normal operation, the *DK* must be power cycled.
- Your antivirus software might try to scan the MSD part of the interface MCU. Some antivirus programs trigger a false positive alert in one of the files and quarantine the unit. If this happens, the interface MCU will become unresponsive.
- If your computer is set up to boot from USB, it can try to boot from the *DK* if the *DK* is connected during boot. This can be avoided by unplugging the *DK* before a computer restart or changing the boot sequence of the computer.

You can also disable the MSD of the kit by using the **msddisable** command in J-Link Commander. To enable, use the **msdenable** command. These commands take effect after a power cycle of the *DK* and stay this way until changed again.

4.1.4 Reset

The nRF9160 DK is equipped with a RESET button (**SW2**).

By default, the RESET button is connected to the interface MCU that will forward the reset signal to the nRF9160 or nRF52840, depending on the state of the nRF52/nRF91 switch. If IF MCU DISCONNECT is activated, the RESET button will be connected to the nRF9160 directly.

4.2 Performance measurement mode

The performance measurement mode can be selected by moving the IFMCU DISCONN switch (**SW1**) to the right position, which disconnects the interface MCU from the nRF9160 SiP using analog switches.

This is done to isolate the nRF9160 SiP as much as possible and can be of use when measuring currents on low-power applications.

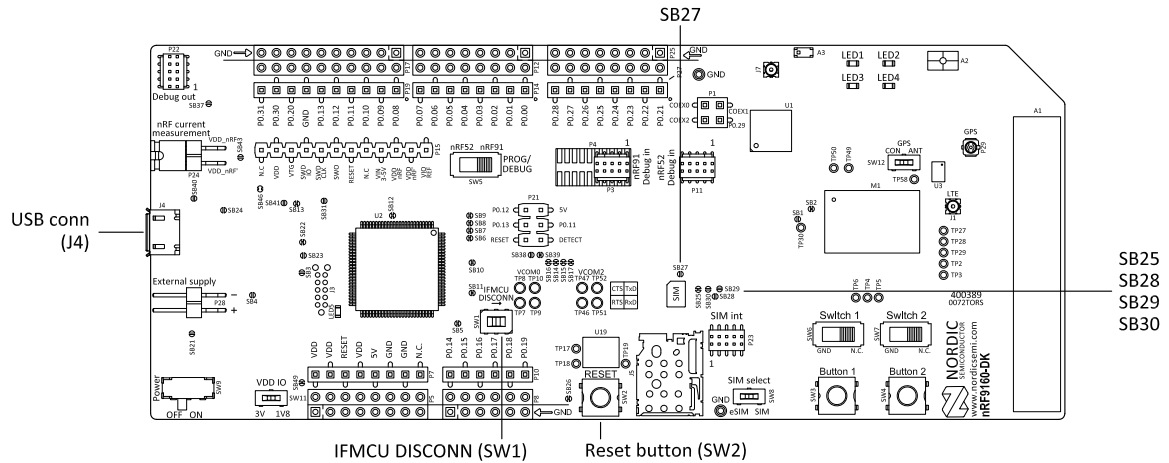


Figure 3: nRF9160 DK performance measurement mode

The DK detects if there is a USB cable plugged in (see [USB detect](#) on page 11) and will disconnect and power down the interface MCU when another supply than the USB is used. If the USB connector is used for power supply only (USB battery back) you can also disable the interface MCU using **SW1**.

USB detect and **SW1** also control the routing of the RESET signal from the RESET button (**SW2**). Normally, it is routed through the interface MCU, but if that is disabled, the reset button will be routed directly to the nRF9160 SiP.

There are also a number of other reset routing options available through the use of solder bridges:

- When the interface MCU is disconnected, the RESET button is connected to pin 32 (nRESET) of the nRF9160 SiP. The RESET button can be disconnected from the nRF9160 SiP by cutting **SB25**.
- When the interface MCU is disconnected, shorting **SB29** will connect the RESET pin of the Arduino interface to the reset pin of the nRF9160 SiP.
- When the interface MCU is connected, shorting **SB30** will connect the RESET pin of the Arduino interface to the BOOT input of the interface MCU.
- Shorting **SB27** will connect the RESET pin of the Arduino interface to the RESET button.
- Shorting **SB28** will connect the RESET pin of the Arduino interface to the nRESET pin of the nRF9160 SiP.

4.2.1 USB detect

To detect when the USB for the interface MCU is connected, there is a circuit sensing the VBUS of USB connector **J4**.

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

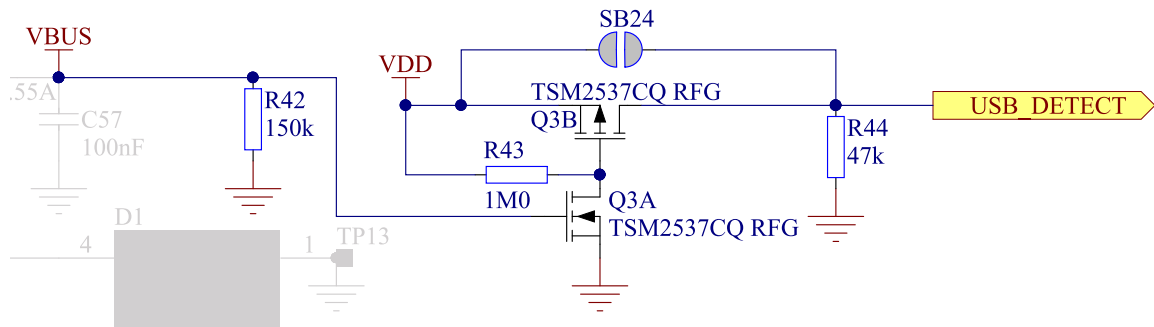


Figure 4: USB detect switch

5 Hardware description

The nRF9160 DK (PCA10090) features an onboard programming and debugging solution.

5.1 Hardware figures

The nRF9160 DK hardware drawings show both sides of the PCA10090.

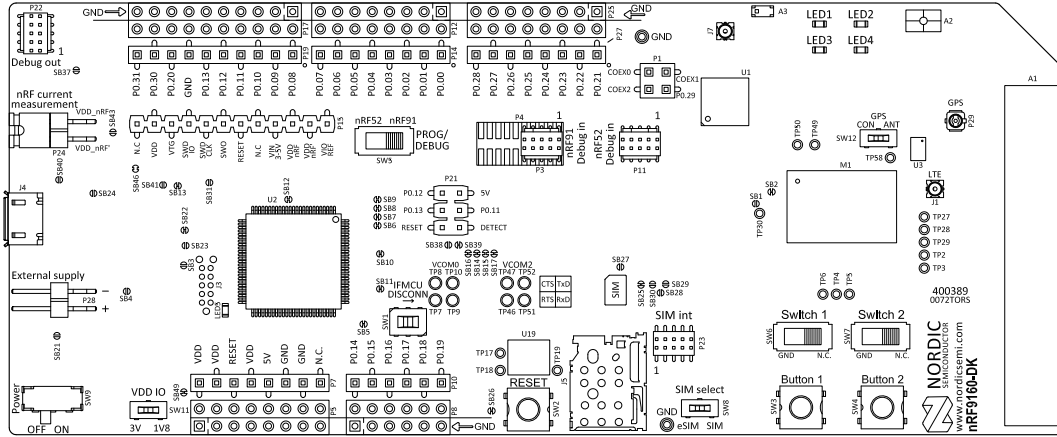


Figure 5: nRF9160 DK (PCA10090), front view

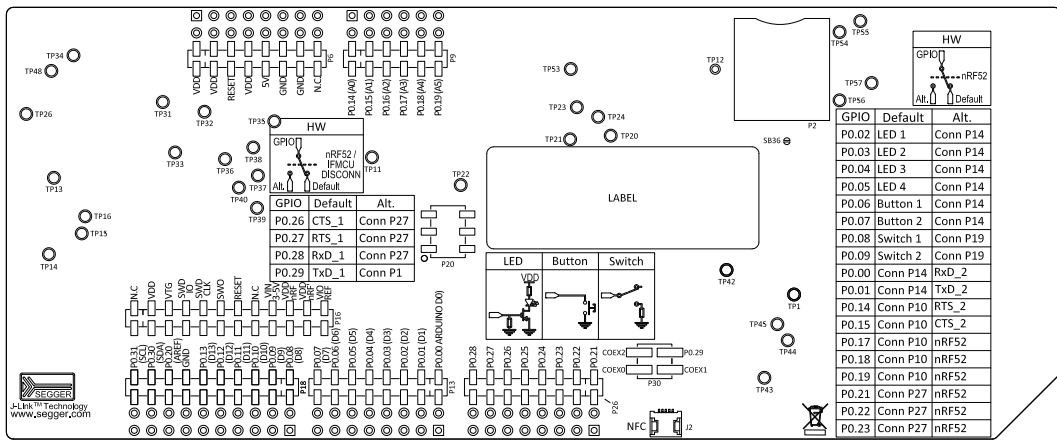


Figure 6: nRF9160 DK (PCA10090), back view

5.2 Block diagram

The block diagram shows the main functionality of the nRF9160 DK.

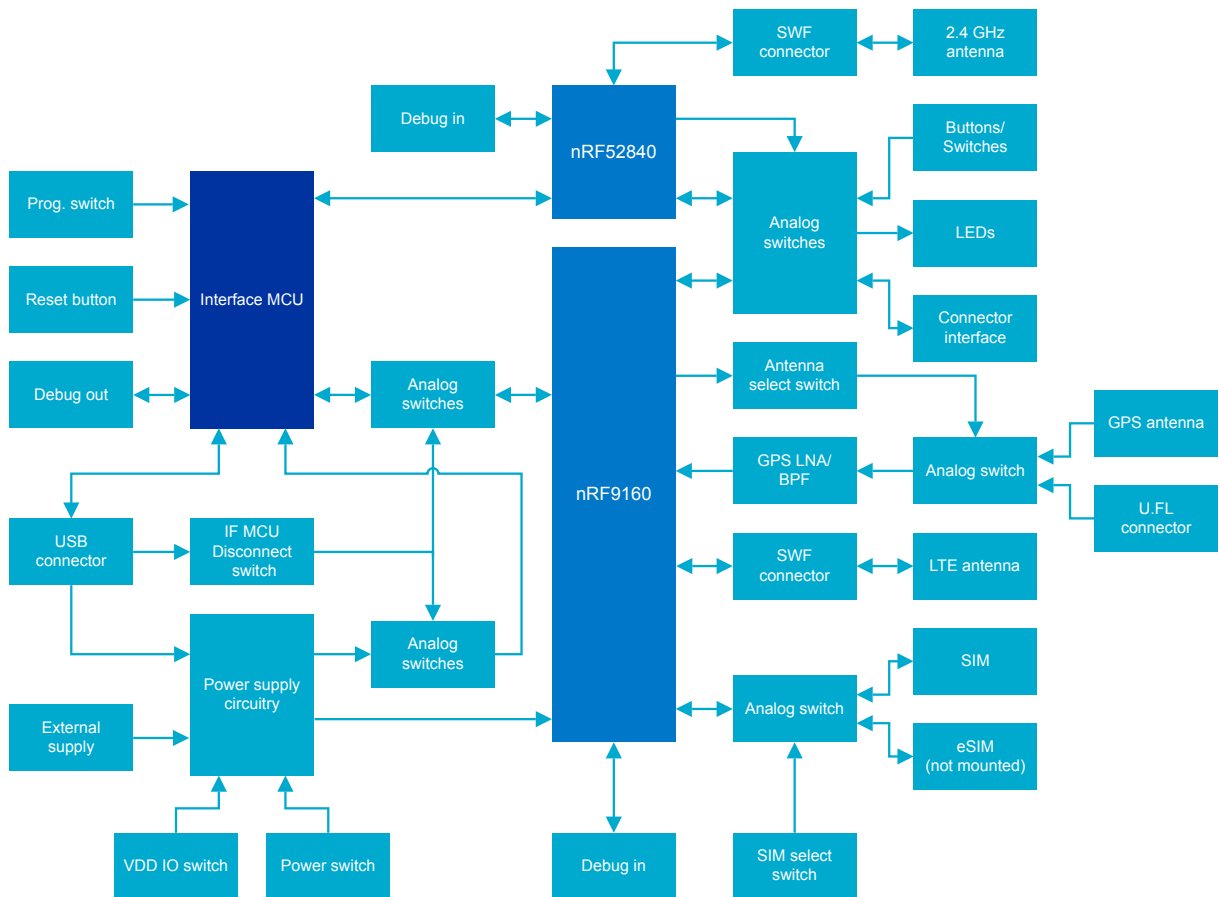


Figure 7: nRF9160 DK block diagram

5.3 Power supply

nRF9160 DK has a flexible and configurable power supply system to allow software development and testing using different power sources and to facilitate accurate power measurements.

The power source options are:

- USB connector **J4** (5 V)
- External supply on **P28** (3.0 V–5.5 V)
- VIN 3–5 V on **P15** (3.0 V–5.5 V)

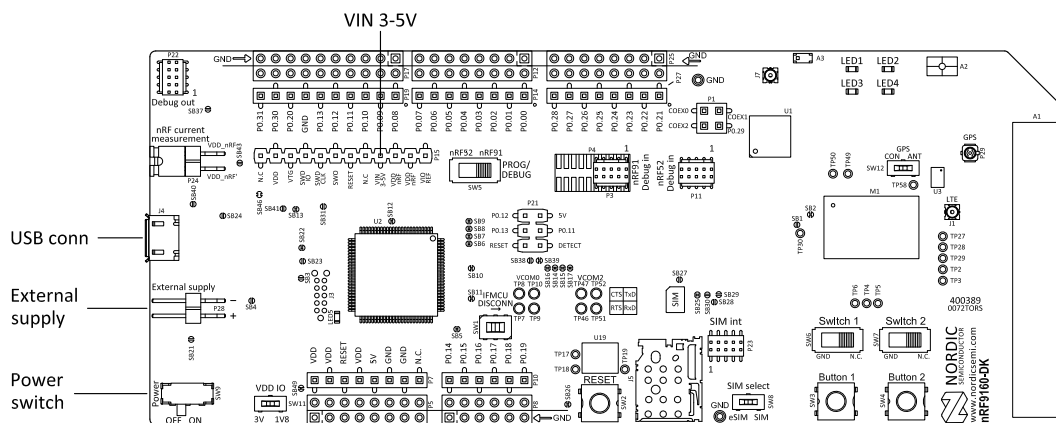


Figure 8: nRF9160 DK power supply options

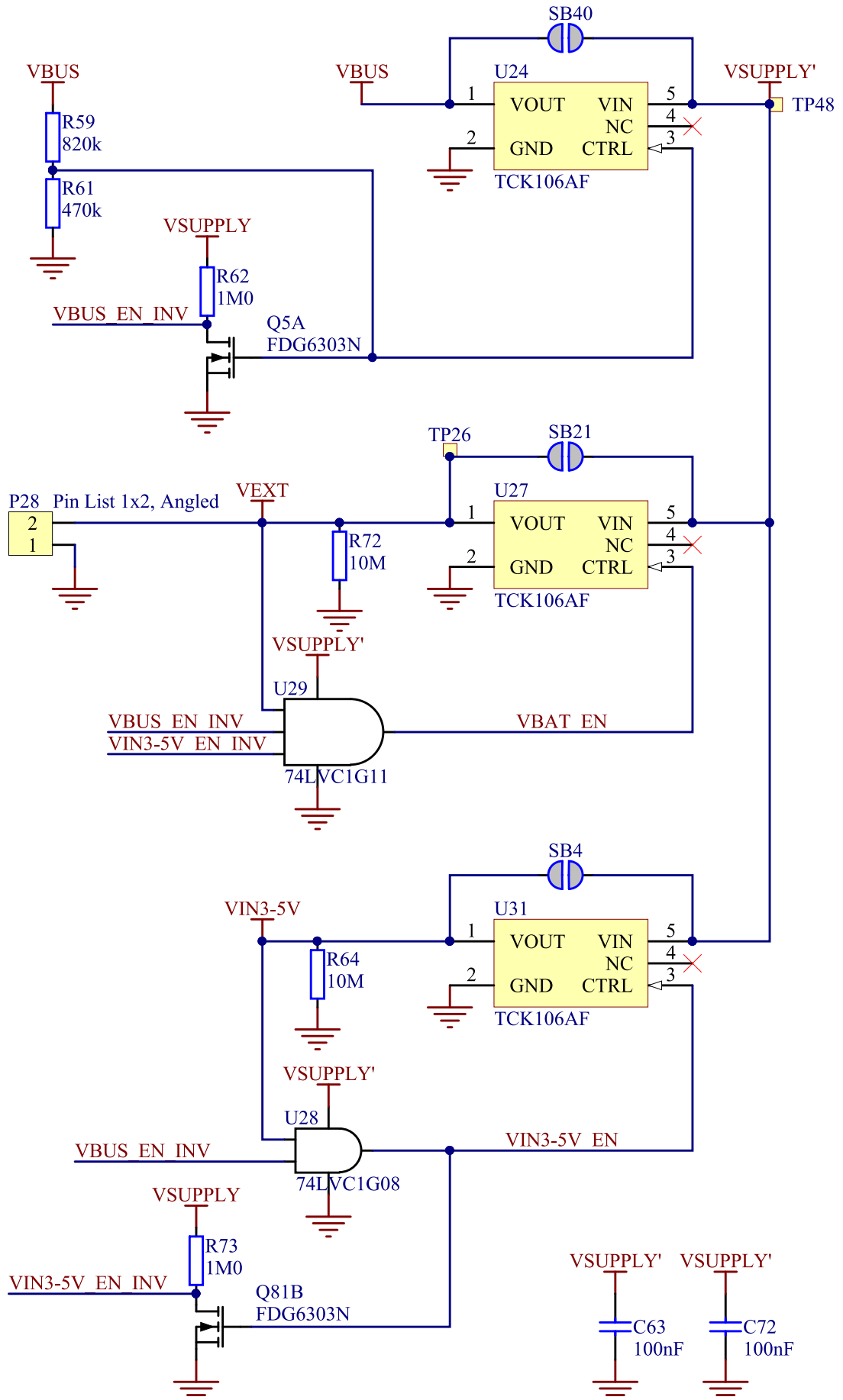


Figure 9: Power sources and switches

To ensure that only one of the power sources are used on the *DK* at a time, power switches are implemented on each of them as shown in [Figure 9: Power sources and switches](#) on page 15. These switches prioritize the supply sources in the following manner:

1. USB
2. P15
3. P28

This means that if power is connected to more than one the interfaces, the higher priority interface will be chosen to supply the *DK*.

The supply voltage is then routed through the ON/OFF switch (**SW9**) to the common rail VSUPPLY, which acts as the source for the supply voltage regulators for the circuitry on the *DK*.

The supply flows from VOUT to VIN, which is correct. The body diode of the internal transistor powers the VSUPPLY net, which supplies the gates controlling the enable signal of the switches.

The power switches will introduce a small voltage drop between the power source connected to the *DK* and the VSUPPLY. To avoid this, the power switches can be bypassed by shorting one of the solder bridges as shown in the table:

Power source	Power switch bypass	Voltage level
USB connector (J4)	SB24	5 V
External supply (P28)	SB36	3.0 V–5.5 V
VIN 3–5 V (P15)	SB4	3.0 V–5.5 V

Table 2: Bypassing power switch

Note: Connect only one power source at a time in this case. Shorting the solder bridges removes the reverse voltage protection.

5.3.1 nRF9160 supply

The nRF9160 has a supply range of 3.0–5.5 V and is therefore powered by the VSUPPLY rail directly.

5.3.2 VDD supply rail

VDD is the main supply for the rest of the circuitry on the *DK*. It is regulated down from VSUPPLY by a buck regulator (**U22**).

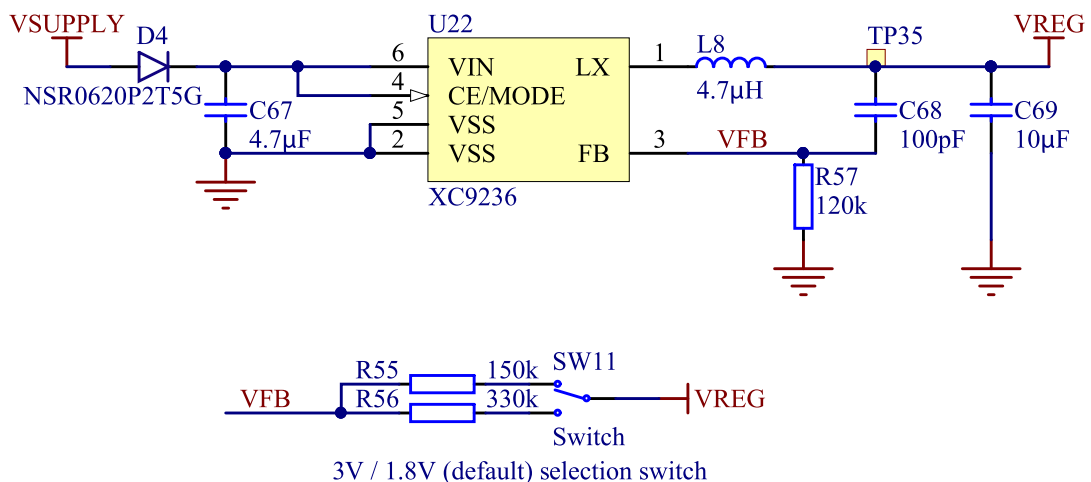


Figure 10: VDD buck regulator and selection switch

You can set the VDD voltage to 1.8 V (default) or 3 V with **SW11**. Running 3 V GPIO with heavy load may degrade the LTE RF performance. A third option for customizing VDD voltage level is applying a custom voltage level to VIO_REF (**P15**). For more information, see [GPIO - General purpose input/output](#) in the nRF9160 Objective Product Specification.

VDD powers most of the other circuits and will set the GPIO signal amplitude between nRF9160 and other circuits on the *DK* including connectors and PIN headers.

5.3.3 Other power domains

The interface MCU needs a 3.0 V for its USB interface supply, a low-dropout voltage regulator (**U32**) is used for this. This regulator also supplies the LEDs on the *DK*, giving these a fixed supply.

5.4 Antenna interfaces

nRF9160 DK has three antenna interfaces mounted representing LTE, GPS, and the 2.4 GHz radio.

The LTE and 2.4 GHz RF signals are propagated through two coaxial connectors with switches that will disconnect the corresponding antenna from the radio if adapter cables are connected. This makes it possible to perform conducted measurements or attach external antennas to the radio.

The *GPS* signal is RX only. There is a *Low-Noise Amplifier (LNA)* and a *Band-Pass Filter (BPF)* that amplify and filter the signal before it is fed to the GPS RF port on the nRF9160. Switch **SW12** controls if the input signal to the LNA is connected to RF connector **P29** or if the signal is routed from the GPS antenna **A2** through switch **U33**. The *LNA* is connected to the GPS antenna by default.

The relation between the connectors, radios, and antennas are the following:

- **J1** – Connector with a switch for the LTE antenna (**A1**)
- **J7** – Debug connector with a switch for the 2.4 GHz antenna (**A3**)
- **P29** – Connector for an external GPS antenna

For more details of the GPS antenna interface, see [GPS](#) on page 17.

5.5 GPS

The nRF9160 has a dedicated *GPS* port to support global navigation.

The *GPS* signal is received either from the onboard or an external GPS antenna. The onboard antenna (**A2**) is connected to the combined *LNA* and *BPF* **U3** through switches **U33** and **U34**.

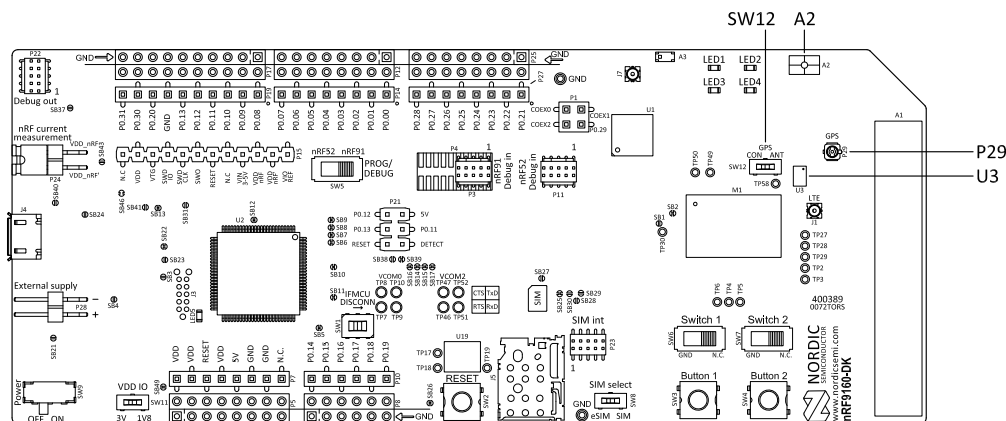


Figure 11: Onboard GPS antenna (A2), LNA/BPF (U3), connector P29, and switch SW12

The onboard antenna can be disconnected and an external GPS antenna enabled by attaching the external GPS antenna to connector **P29** and sliding switch **SW12** to CON position. 3.0 V DC is fed through **P29** to supply an external LNA, if desired. The external GPS antenna can be connected to connector **P29** (Hirose part no. U.FL-R-SMT-1). A compatible adapter cable is required to connect a GPS antenna to the *DK*.

Switch **U34** and the combined LNA and BPF are enabled by the GPS-enable signal from the nRF9160.

The signal is next amplified and filtered in the *LNA* and *BPF* **U3** before it is fed to the nRF9160. This makes the GPS receiver more sensitive to GPS signals and less sensitive to interference from other sources on the *DK* or nearby.

Note:

- GPS signals do not usually penetrate ceilings or other structures that well. Therefore, for best GPS performance, the *DK* should be placed on a flat surface in an open space outside, far from sources of interference and other structures that may block the signals from space.
- This functionality is only available if the modem firmware used in the nRF9160 supports GPS.
- 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 GPS signals. A lower gain will be experienced if the patch antenna is mounted on a surface is at an angle with the horizontal surface.

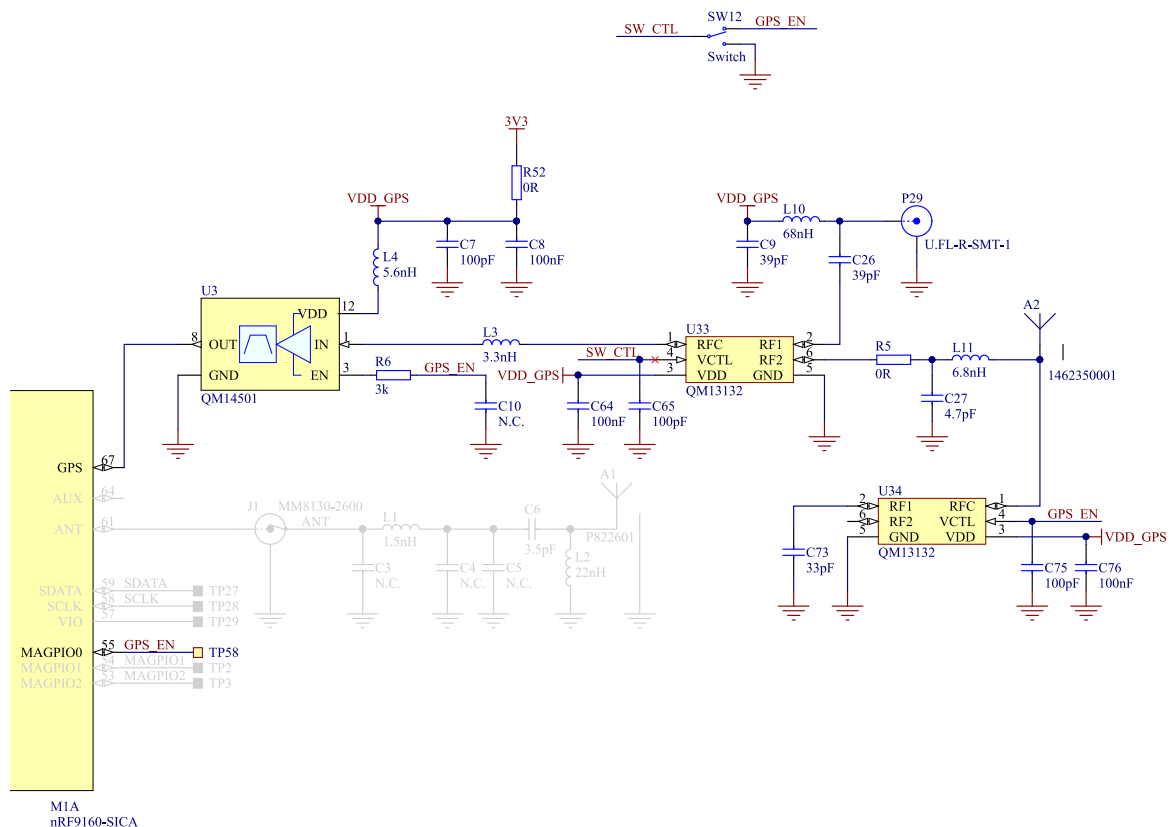


Figure 12: GPS connected to the nRF9160

5.6 GPIO interfaces

Access to the nRF9160 GPIOs is available from connectors **P7**, **P10**, **P14**, **P19**, and **P27**. The nRF9160 *DK* supports the Arduino UNO interface.

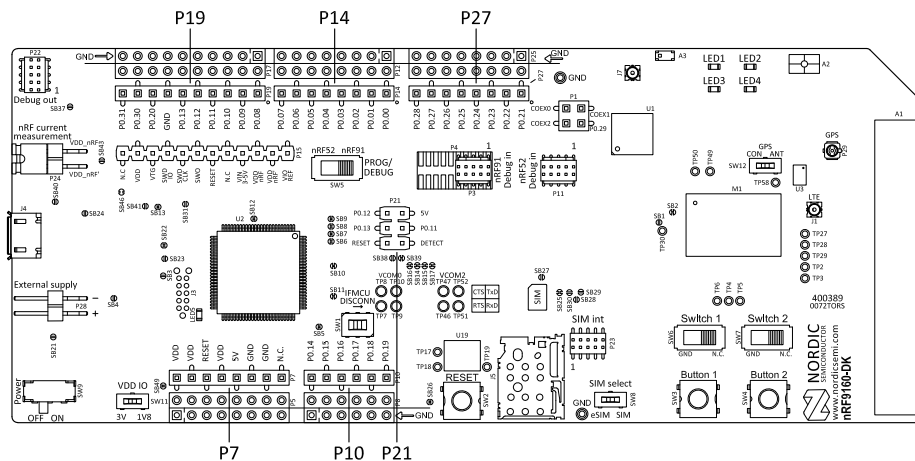


Figure 13: Access to nRF9160 GPIOs

GPIO signals are also available on connectors **P5**, **P6**, **P12**, **P17**, and **P25**, which are on the bottom side of the DK. By mounting pin lists on the connector footprints, the nRF9160 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 **P8**, **P12**, **P17**, and **P25**.

Note: GPIO **P0.29** is not available on any through-hole connector.

GPIO nRF9160 DK	Function
P0.00, P0.01, P0.14, and P0.15	Used as a second UART connection to the interface MCU. For more information, see Virtual COM port on page 9.
P0.02, P0.03, P0.04, P0.05, P0.06, P0.07, P0.08, and P0.09	Connected by default to buttons, slide switches, and LEDs. For more information, see Buttons, slide switches, and LEDs on page 23.
P0.17, P0.18, P0.19, P0.21, P0.22, P0.23, COEX0, COEX1, and COEX2	Used to connect the nRF9160 to the nRF9160 DK board control on page 21.
P0.26, P0.27, P0.28, and P0.29	Used as the primary UART connection to the interface MCU. For more information, see Virtual COM port on page 9.

Table 3: Default pin settings

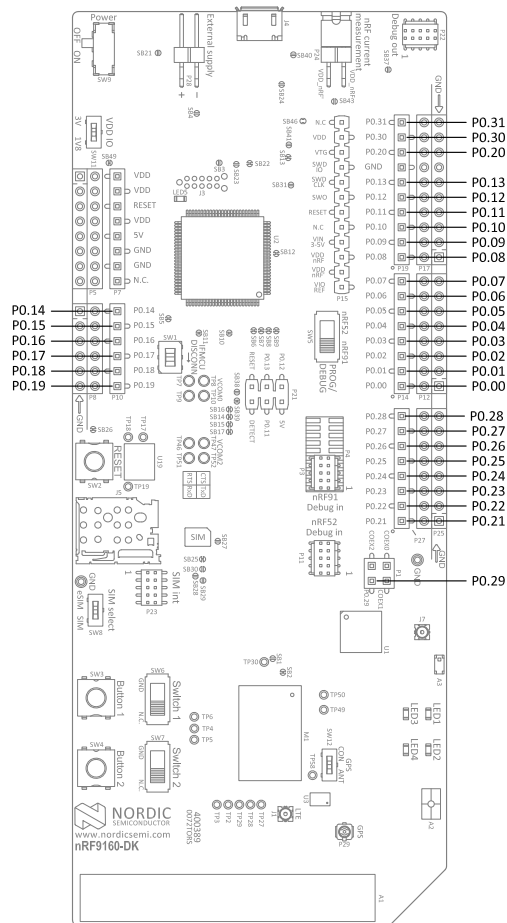


Figure 14: nRF9160 DK pins

5.7 nRF52840

An nRF52840 Bluetooth/IEEE 802.15.4 System on Chip (SoC) is included on the nRF9160 DK.

This device has two functions:

- nRF9160 DK control
- Bluetooth/IEEE 802.15.4 network processor

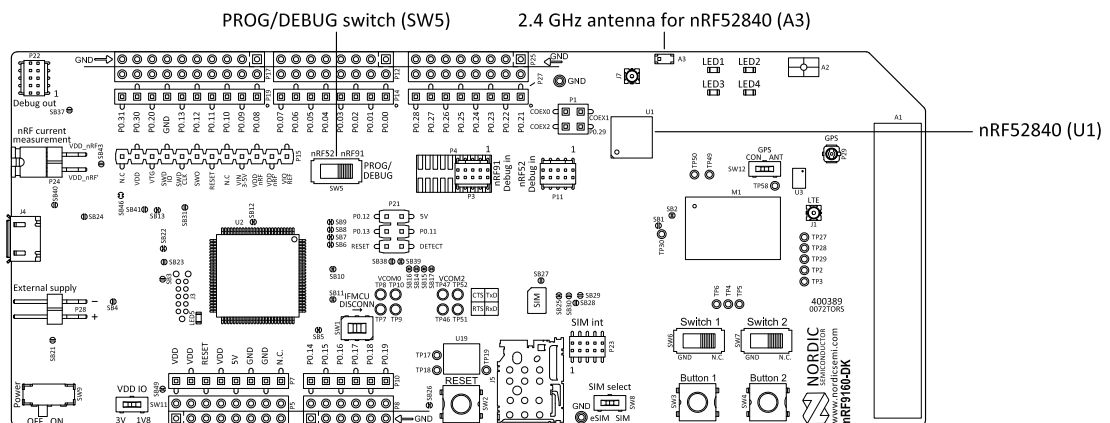


Figure 15: nRF52840 SoC on the nRF9160 DK

5.7.1 nRF9160 DK board control

The nRF52840 controls analog switches on the nRF9160 DK, enabling routing of some of the nRF9160 GPIO pins to onboard functionality, for example LEDs, or the regular GPIO interfaces.

For details on which GPIOs on the nRF9160 can be routed by these analog switches, see the table below.

Name	nRF52 control GPIO	nRF9160 GPIO	Destination ¹	
			Default	Optional
nRF91_APP1	P1.14	P0.26	VCOM0_RTS	P27_pin6
		P0.27	VCOM0_CTS	P27_pin7
		P0.28	VCOM0_TXD	P27_pin8
		P0.29	VCOM0_RXD	P1_pin4
nRF91_APP2	P1.12	P0.01	P14_pin2	VCOM2_RXD
		P0.00	P14_pin1	VCOM2_TXD
		P0.15	P10_pin2	VCOM2_RTS
		P0.14	P10_pin1	VCOM2_CTS
nRF91_LED1	P1.05	P0.02	LED1	P14_pin3
nRF91_LED2	P1.07	P0.03	LED2	P14_pin4
nRF91_LED3	P1.01	P0.04	LED3	P14_pin5
nRF91_LED4	P1.03	P0.05	LED4	P14_pin6
nRF91_SWITCH1	P1.09	P0.08	SWITCH1	P19_pin1
nRF91_SWITCH2	P0.08	P0.09	SWITCH2	P19_pin2
nRF91_BUTTON1	P0.06	P0.06	BUTTON1	P14_pin7
nRF91_BUTTON2	P0.26	P0.07	BUTTON2	P14_pin8
nRF91_GPIO	P0.13	P0.17	P10_pin4	nRF52_P0.17
		P0.18	P10_pin5	nRF52_P0.20
		P0.19	P10_pin6	nRF52_P0.15
NRF91_TRACE	P0.24	P0.21	P4_TRACECLK	nRF52_P0.22
		P0.22	P4_TRACEDATA0	nRF52_P1.04
		P0.23	P4_TRACEDATA1	nRF52_P1.02
NRF91_COEX	P1.10	COEX0	P1_COEX0_PH	nRF52_P1.13
		COEX1	P1_COEX1_PH	nRF52_P1.11
		COEX2	P1_COEX2_PH	nRF52_P1.15

Table 4: Board control routing

Name

The name to be used when referring to this signal path and the configuration needed to control it.

¹ For the location of connectors, see [Figure 5: nRF9160 DK \(PCA10090\), front view](#) on page 13

nRF52 switch control

The GPIOs on nRF52840 that are used to control the analog switches selecting between default and optional routing.

Source nRF9160

The GPIOs on nRF9160 that can be configured to have an alternative routing.

Destination "Default"

The default destination for the "Source nRF9160" if the "nRF52 switch control" pins are set as output and pin driver is low.

Destination "Optional"

The optional destination for the "Source nRF9160" if the "nRF52 switch control" pins are set as output and pin driver is high.

The setup described as "Destination Default" in the table above is active if all the GPIOs on nRF52840 listed as "nRF52 switch control" are set as output and driven low. There is a pull-down resistor on the switch control lines, and therefore, "Destination Default" can also be received if the control lines from the nRF52840 are not driven. If the optional routing is desired, the "nRF52840 switch control" pins have to be set as outputs and driven high.

The nRF52840 is preprogrammed with firmware that provides the default destination setting. Configurable code examples for the nRF52840 allowing to change the board routing can be found in the nRF Connect SDK. After the changes are done, the new program must be compiled and programmed to the nRF52840.

Note: To program and debug the nRF52840, nRF52 needs to be selected on the PROG/DEBUG switch (**SW5**).

Since this firmware in the nRF52840 decides the nRF9160 DK behavior, it is vital that it is always present in the nRF52840. If it is accidentally erased or firmware affecting the use of the key nRF52840 GPIOs is programmed in, nRF9160 DK functionality is not guaranteed. In such cases, nRF52840 needs to be preprogrammed with the default board control firmware from the nRF Connect SDK.

5.7.2 Bluetooth/IEEE 802.15.4 network processor

A second function of the onboard nRF52840 is to act as a Bluetooth or IEEE 802.15.4 network processor. This makes it possible to develop products that utilize both LTE and other RF protocols supported by Nordic on the nRF9160 DK.

Since most of the GPIOs of the nRF52840 are used for board control (see the schematic below), it is not intended to be a full programming and development target on the nRF9160 DK.

However, if combined with board control firmware, it can run code that requires limited access to GPIO, such as wireless controllers or network processor implementations of Bluetooth and IEEE 802.15.4 protocols from Nordic Semiconductor.

This enables the nRF9160 DK to implement a cellular to Bluetooth (and/or IEEE 802.15.4) bridge or gateway. To enable this, nRF52840 has a 2.4 GHz antenna fitted along with nine GPIOs that can be connected to nRF9160 through the board control routing. For details, see [Table 4: Board control routing](#) on page 21.

Firmware examples for such bridge or gateway implementations can be found in [nRF9160: LTE Sensor Gateway](#).

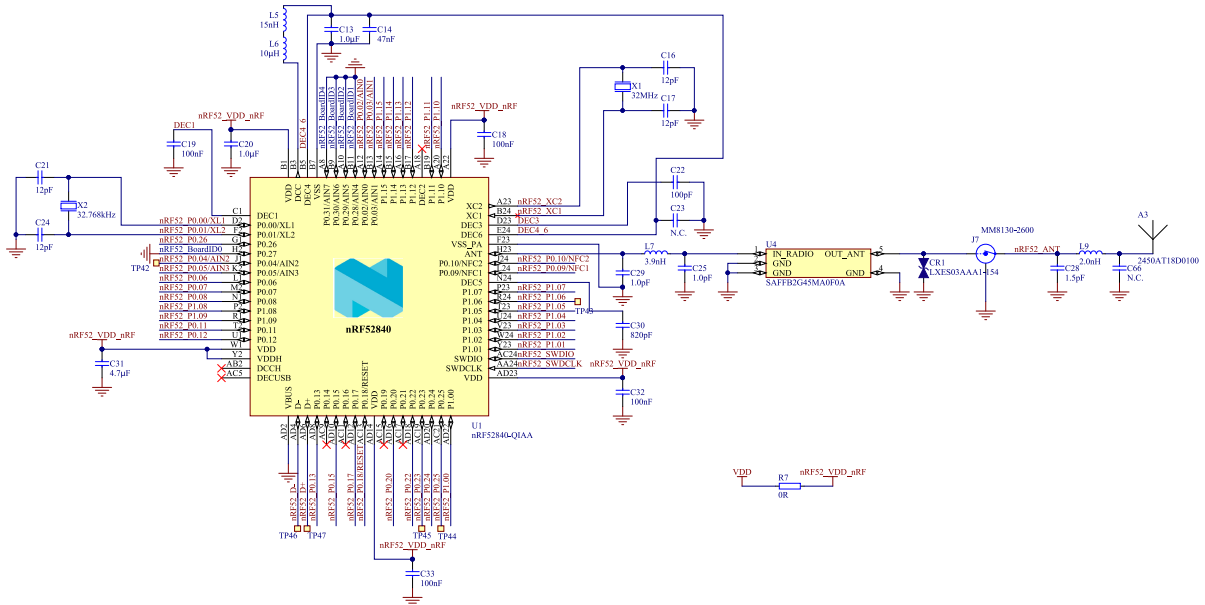


Figure 16: nRF52840 board controller

5.8 Buttons, slide switches, and LEDs

The nRF9160 DK has four LEDs, two buttons, and two switches for simple user interaction. By default, they are connected to nRF9160 GPIOs as shown in the following table.

To change default nRF9160 GPIO connections, see [nRF9160 DK board control](#) on page 21

Part	GPIO
LED 1	P0.02
LED 2	P0.03
LED 3	P0.04
LED 4	P0.05
Button1	P0.06
Button2	P0.07
Switch1	P0.08
Switch2	P0.09

Table 5: Button and LED connection

The nRF52840 can be used to disconnect any of the LEDs, slide switches, or buttons.

The buttons and switches are active low, meaning that the input will be connected to ground when the buttons are pushed or switches slid to the GND position. The buttons and switches have no external pull-up resistor, and therefore the **P0.06**, **P0.07**, **P0.08**, and **P0.09** 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 will illuminate the LED. The nRF9160 GPIOs control power transistors and LEDs are fed from a separate 3.0 V domain. Therefore, LED current will not be drawn from nRF9160 GPIOs or the nRF9160 supply.

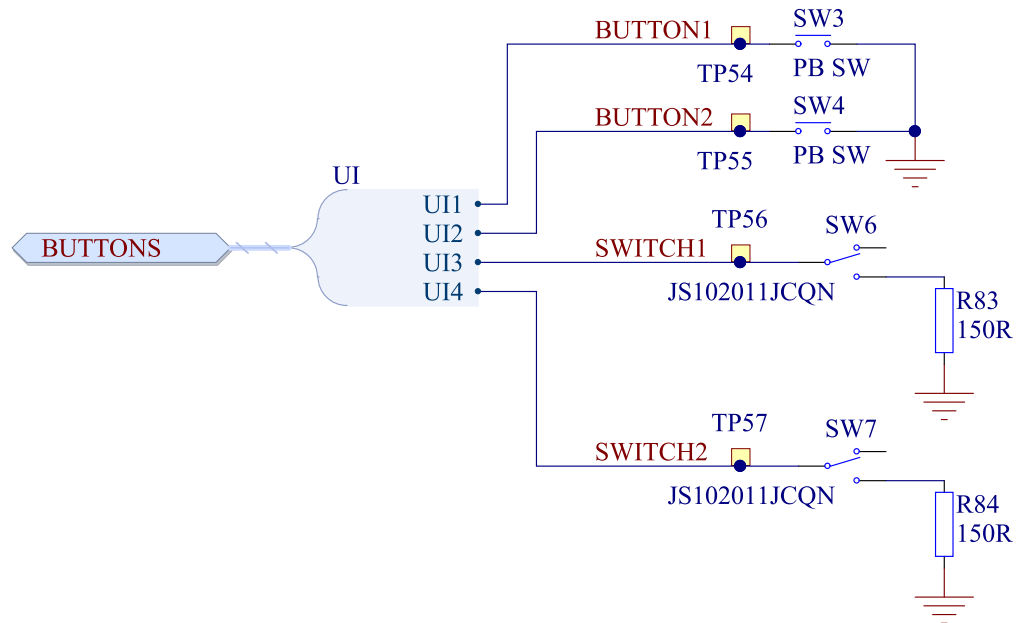


Figure 17: Buttons and switches

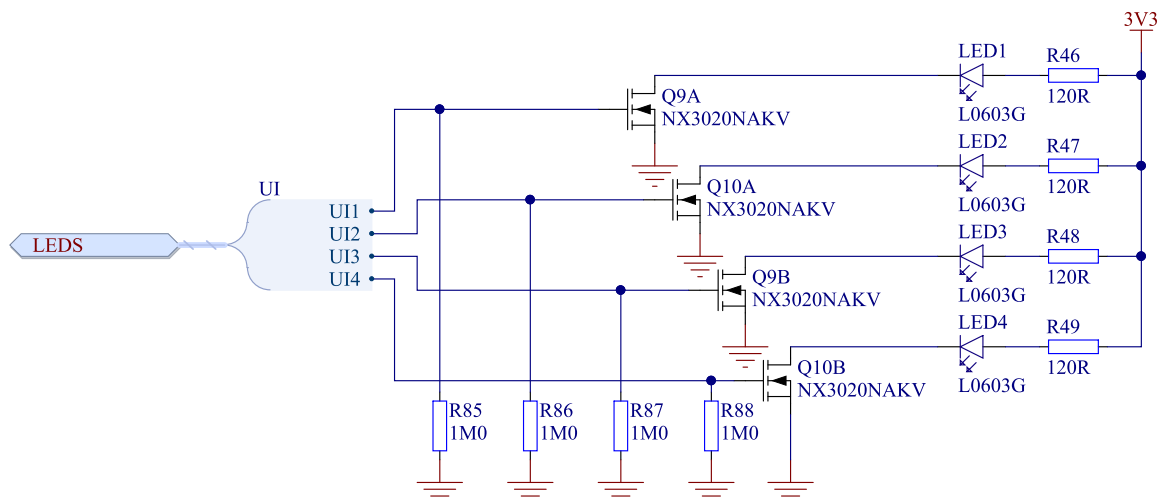


Figure 18: LEDs

5.9 Debug input and trace options

The primary debug interface on the nRF9160 DK is the Segger OB debugger available through the USB port. However, if other than USB supply is used on the *DK*, this functionality will be disabled.

The Debug in connectors **P3** (nRF9160) and **P11** (nRF52840) make 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.

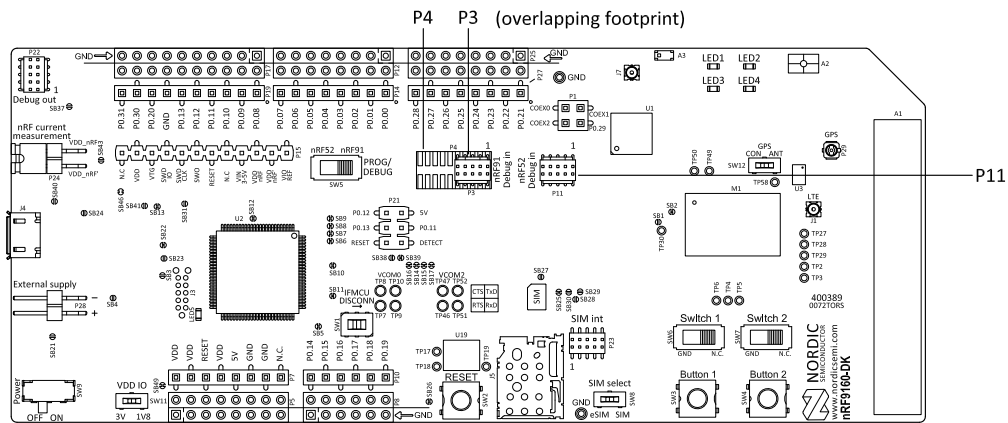


Figure 19: Debug input connector and trace footprint

To utilize the SW trace feature on nRF9160, a footprint for a 20-pin connector is available (**P4**). If trace functionality is required, a 2×10 pin 1.27 mm pitch surface mount connector can be mounted. nRF9160 GPIOs used for the trace interface will not be available for application firmware use during trace.

Note: Connectors **P3** and **P4** overlap and share the same footprint.

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

Table 6: nRF9160 trace interfaces

5.10 Debug output

The nRF9160 DK supports programming and debugging external boards with Nordic SoCs and SiPs.

To debug an external board with SEGGER J-Link OB IF, connect the Debug out connector **P22** to your target board with a 10-pin flat cable.

Pin number	Signal	Description
1	SWD0_SELECT	Voltage supply from the external target, used as voltage detect input to the interface MCU
2	SWD0_SWDIO	Serial Wire Debug (SWD) data line
3	GND	Ground
4	SWD0_SWDCLK	SWD clock line
5	GND	Ground
6	SWD0_SWO	Serial Wire Output (SWO) line
7	N.C.	Not used
8	N.C.	Not used
9	N.C.	Not used
10	SWD0_RESET	Reset

Table 7: Pinout of connector P22 for programming external targets

Pin number	Signal	Description
1	N.C.	Not used
2	VDD	Used for VDD voltage
3	SWD1_SELECT	Voltage supply from the external target, used as voltage detect input to the interface MCU
4	SWD1_SWDIO	Serial Wire Debug (SWD) data line
5	SWD1_SWDCLK	SWD clock line
6	SWD1_SWO	Serial Wire Output (SWO) line
7	SWD1_RESET	Reset line
8	N.C.	Not used
9	VIN3-5V	Voltage supply
9	VDD_HV	Used for current measurement
10	VDD_HV'	Used for current measurement
12	VIO_REF	GPIO voltage reference input

Table 8: Pinout of connector P15 for programming target on shields

5.11 Signal routing switches

A number of the GPIO signals of the nRF9160 are routed through analog switches for use for onboard functionality or having them available on the pin headers for external circuitry or Arduino type shields.

5.11.1 Interface MCU disconnect switches

The IF MCU DISCONNECT mode can be enabled using the switches shown in the schematics.

For more information, see [Performance measurement mode](#) on page 11.

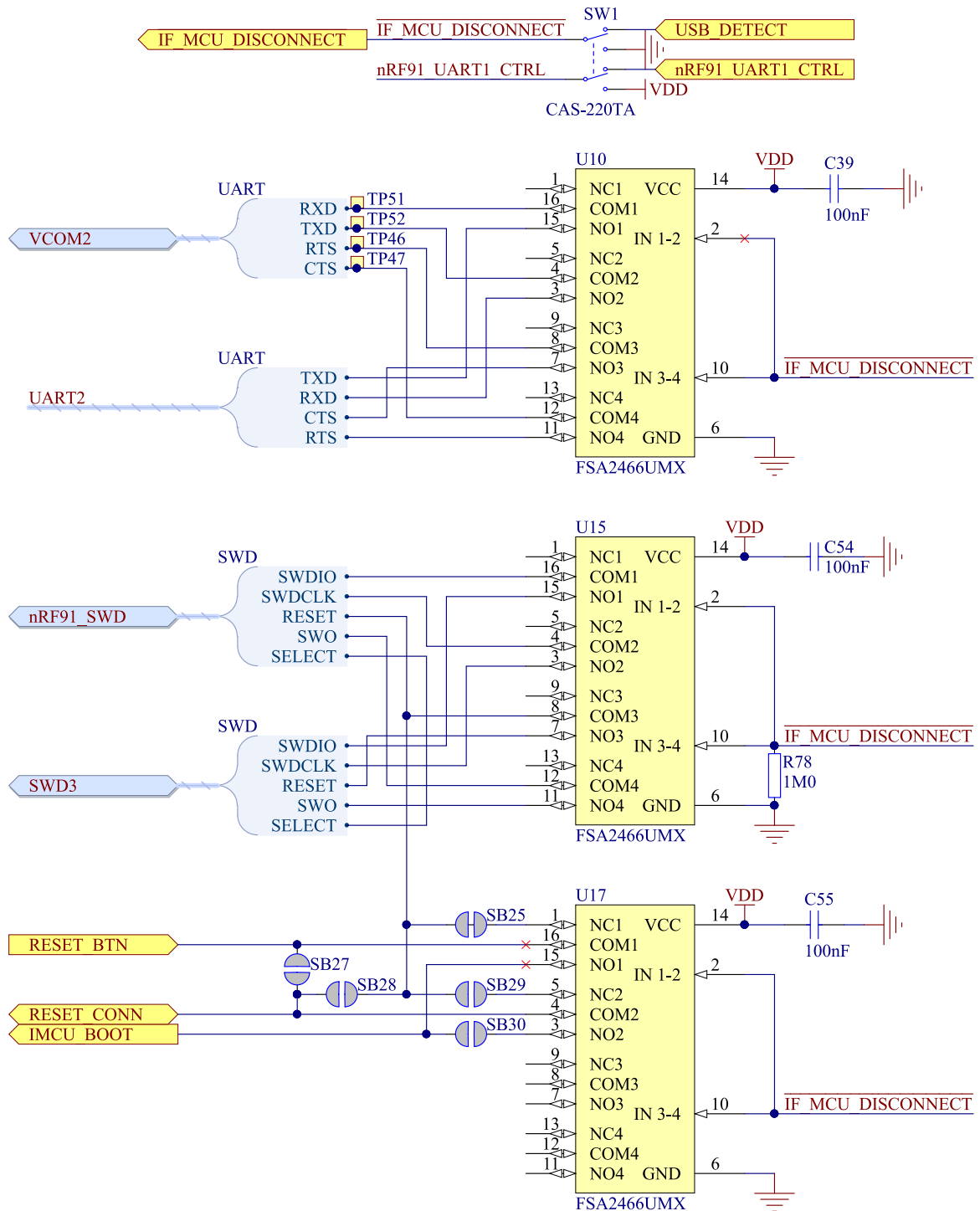


Figure 21: Signal interface switches

5.11.2 Switches for UART interface

Two UART interfaces are routed between the interface MCU and the nRF9160 SiP. These can be controlled individually.

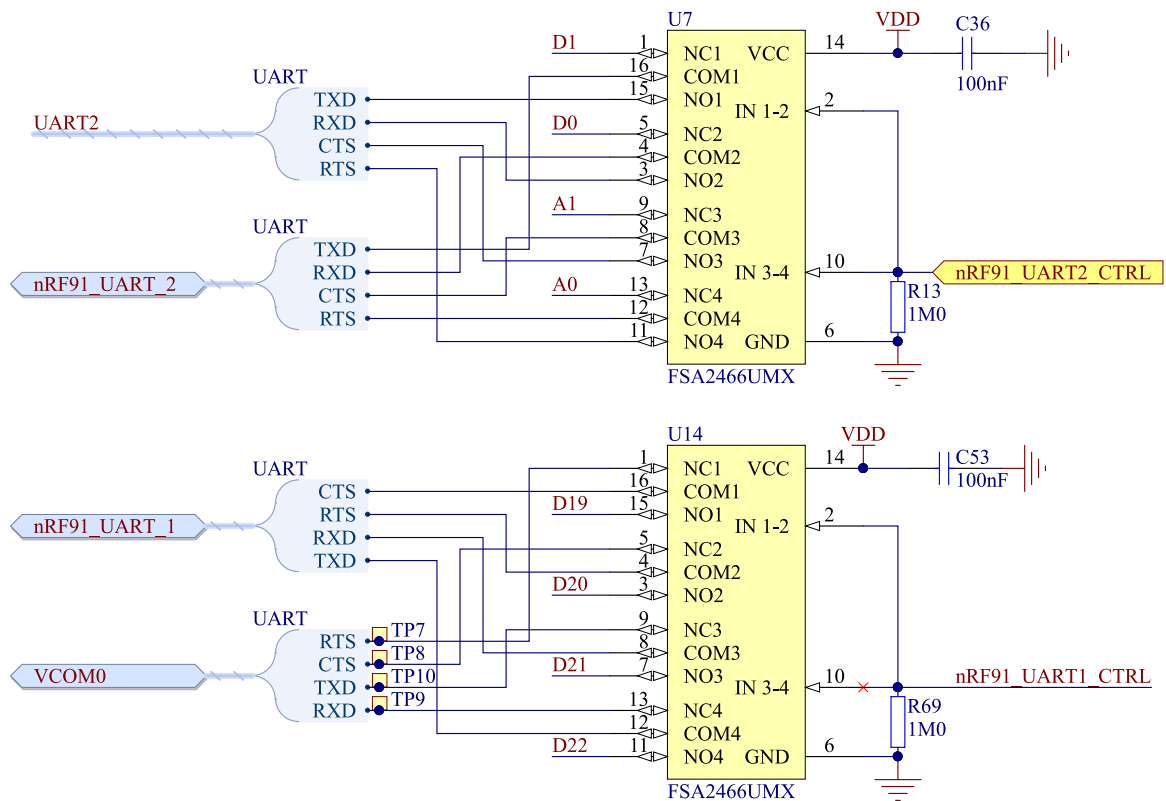


Figure 22: UART interface switches

5.11.3 Switches for buttons and LEDs

On the nRF9160 DK, there are a few analog switches that are used to connect and disconnect signals to control buttons, switches, and LEDs.

The switches are controlled by the nRF52840, which contains firmware from Nordic Semiconductor.

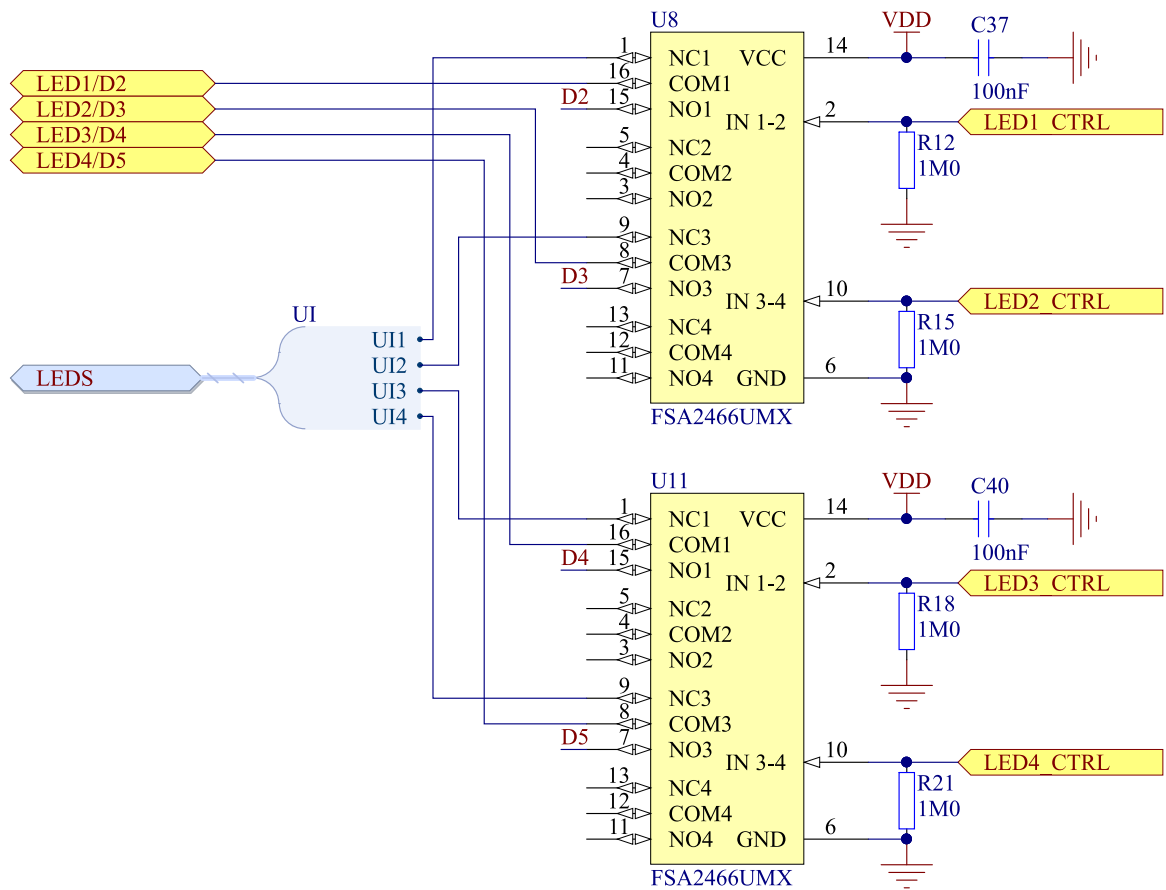


Figure 23: LED switch control

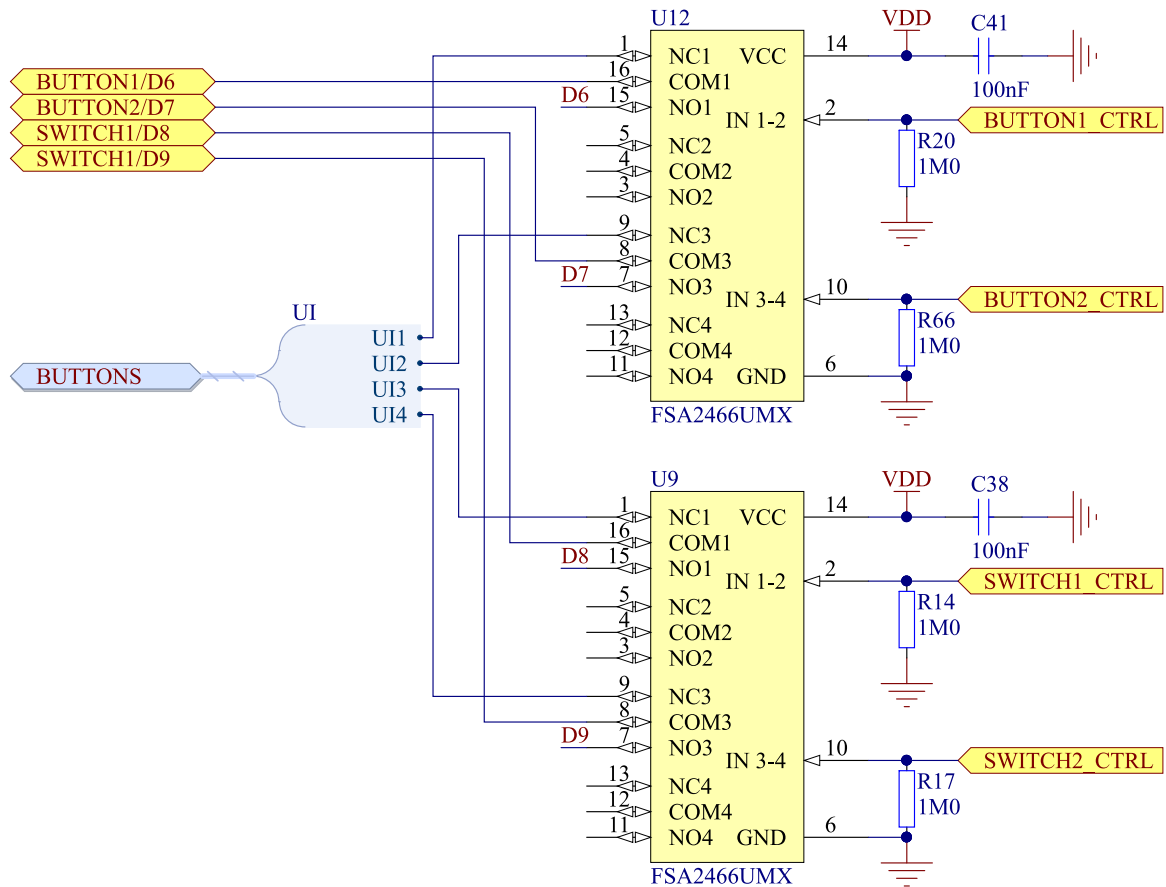


Figure 24: Buttons and switches, switch control

5.11.4 Switches for nRF52840 interface

A total of three analog switches controls the routing of signals between the nRF9160 SiP and the nRF52840 SoC. There are a total of nine signals that can be routed between the devices, six GPIOs and three COEX pins.

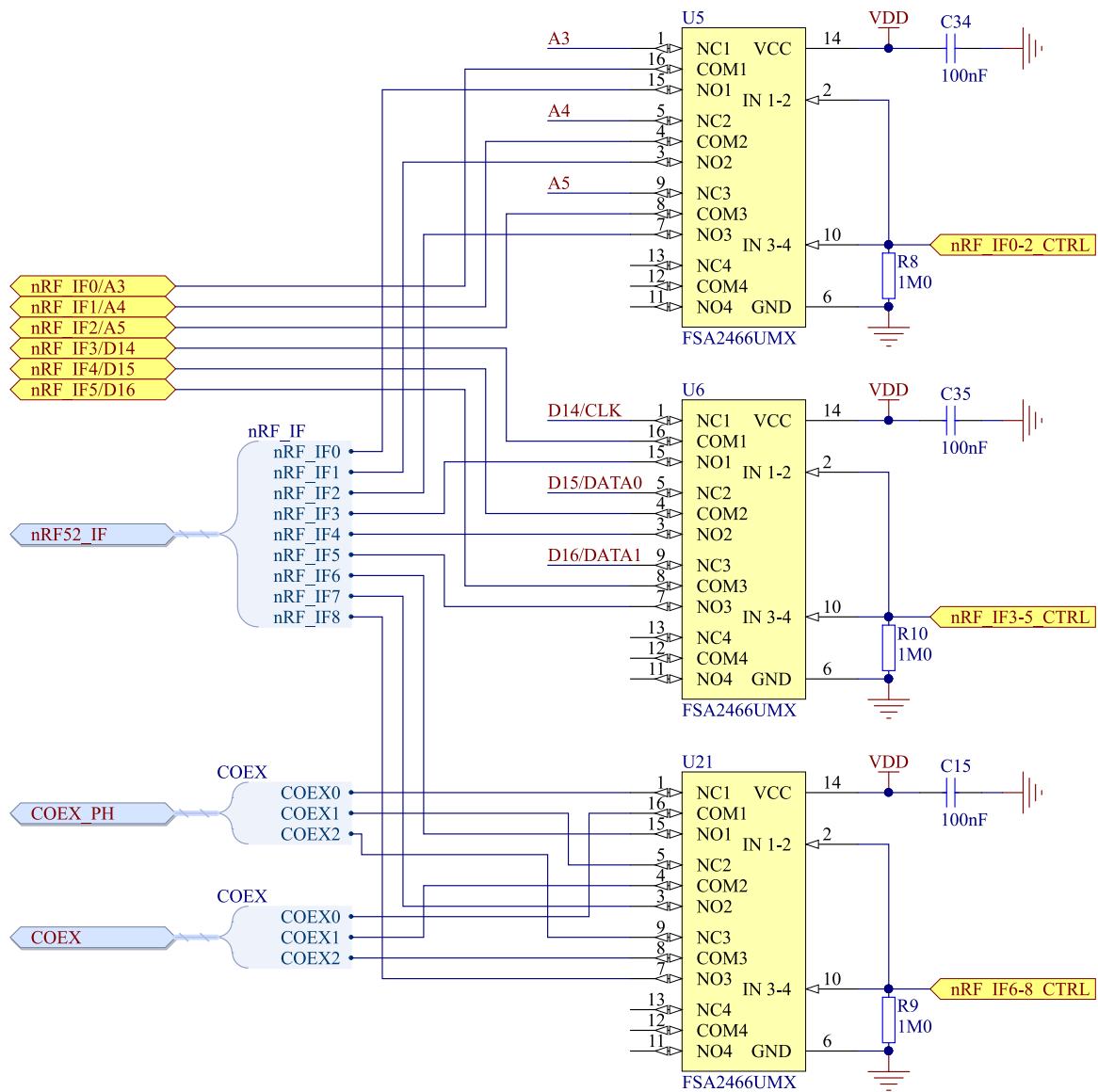


Figure 25: nRF52840 interface switches

5.12 SIM and eSIM

The nRF9160 DK is designed to support both regular and embedded SIM (eSIM). For this purpose, it has a pluggable SIM card socket 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 on to the DK, switch **SW8** can be used to select the eSIM. Connector **P23** can be used to connect and monitor the traffic on the SIM interface.

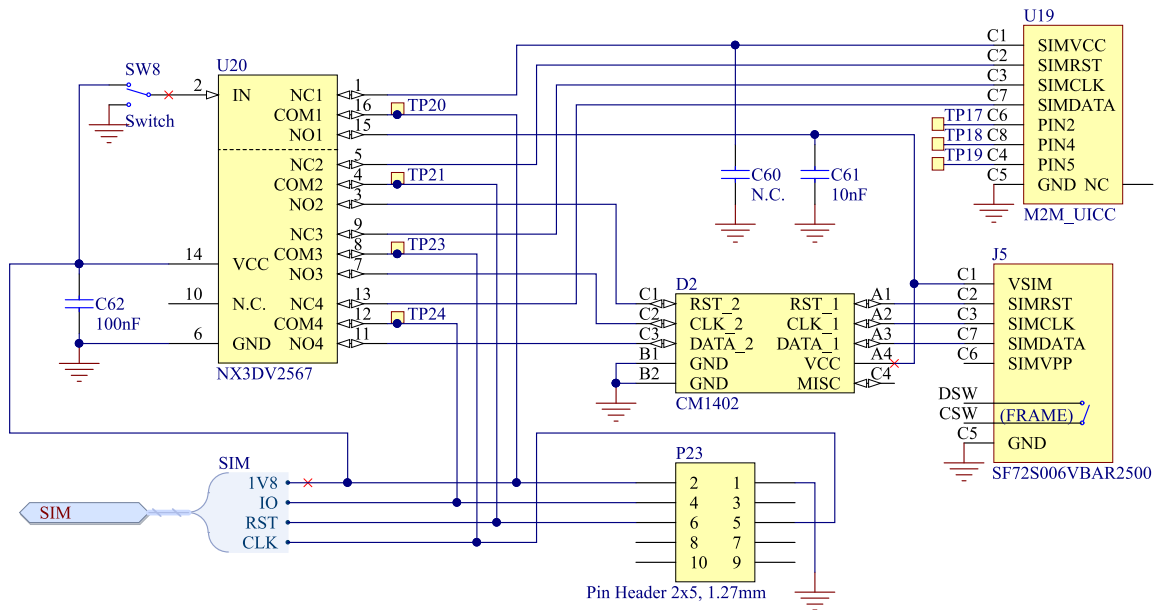


Figure 26: SIM card connector, eSIM, and selection switch

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

5.13 Additional interfaces

The nRF9160 DK supports a few dedicated interfaces.

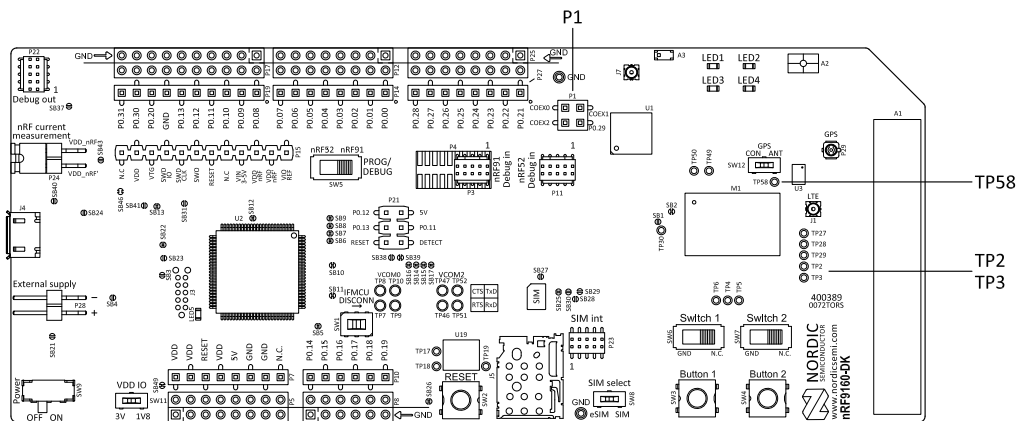


Figure 27: SiP external interfaces

Coexistence pins

On the nRF9160 DK, there are three COEX pins enabling coexistence handling between multiple wireless devices. These pins are routed to the nRF52840 for use when nRF52840 is used as a network processor. These signals are also available on connector **P1**.

MAGPIO

nRF9160 has an interface allowing the modem to control external circuitry through the MAGPIO pins. On the nRF9160 DK, MAGPIO0 is used to enable the *GPS LNA*, while the remaining two MAGPIOs are not in use in this *DK*. The user can access MAGPIO0, MAGPIO1, and MAGPIO2 through test points **TP58**, **TP2**, and **TP3**.

5.14 SiP enable

The *SiP* can be enabled or disabled by pulling pin **101** high and low.

By default, the enable signal is pulled high by resistor **R3**. To disable the SiP, connect to test point **TP1** (on the back of the *DK*) and pull the pin low.

5.15 Solder bridge configuration

The nRF9160 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 nRF9160 DK.

Solder bridge	Default	Function
SB2	Closed	Cut to disconnect VDD_GPIO supply to the nRF9160 SiP
SB3	Open	Short to bypass switch U26
SB4	Open	Short to bypass the VIN3–5 V switch U31
SB5	Closed	Cut to disconnect the RESET signal from the nRF52840 SoC
SB6	Closed	Cut to disconnect RTS signal from the nRF52840 SoC
SB7	Closed	Cut to disconnect CTS signal from the nRF52840 SoC
SB8	Closed	Cut to disconnect RXD signal from the nRF52840 SoC
SB9	Closed	Cut to disconnect TXD signal from the nRF52840 SoC
SB10	Closed	Cut to disconnect SWDIO from the nRF52840 SoC
SB11	Closed	Cut to disconnect SWDCLK from the nRF52840 SoC
SB12	Closed	Cut to disconnect the 3.0 V USB supply from the interface MCU (U2)
SB13	Closed	Cut to disconnect supply to LDO (U32)
SB14	Closed	Cut to disconnect RTS from the nRF9160 SiP
SB15	Closed	Cut to disconnect RTS from the nRF9160 SiP
SB16	Closed	Cut to disconnect RXD from the nRF9160 SiP
SB17	Closed	Cut to disconnect TXD from the nRF9160 SiP
SB21	Open	Short to bypass the external supply switch U27
SB22	Closed	Cut to disconnect supply from Arduino interface
SB23	Open	Short to bypass Arduino 5 V reverse protection diode D3
SB24	Open	Short to bypass the USB detect switch (Q3)
SB25	Closed	Cut to disconnect the RESET button from the nRF9160 reset pin when the interface MCU is disconnected
SB26	Closed	Cut to disable the pull-up resistor of the RESET button (SW2)
SB27	Open	Short to connect the RESET button to the RESET pin on the Arduino interface

Solder bridge	Default	Function
SB28	Open	Short to connect the RESET pin on the Arduino interface to the nRF9160 reset pin
SB29	Open	Short to connect the RESET pin on the Arduino interface to the nRF9160 reset pin when the interface MCU is disconnected
SB30	Open	Short to connect the RESET pin on the Arduino interface to the interface MCU Boot when the interface MCU is disconnected
SB31	Open	Short to bypass the VDD_IMCU_3V3 switch (U18)
SB36	Open	Short to connect DBG_CMD to the SD card reader P2 (not populated by default)
SB37	Open	Short to enable power supply of the external device when using the Debug out connector (P22)
SB38	Open	Short to permanently enable the SHIELD DETECT feature
SB39	Closed	Cut to permanently disable SHIELD DETECT feature
SB40	Open	Short to bypass the USB supply switch (U24)
SB41	Open	Short to bypass the VDD_IMCU switch (U30)
SB43	Open	Short to connect VDD_nRF and VDD_nRF'
SB46	Closed	Cut to disconnect the VSUPPLY and VDD_nRF'
SB49	Closed	Cut to disconnect VDD and VIO

Table 9: Solder bridge configuration

6 Measuring current

The current drawn by the nRF9160 can be monitored on the nRF9160 DK.

Current can be measured using various test instruments. Examples of test equipment are the following:

- Power analyzer
- Oscilloscope
- Ampere-meter

Connector **P24** can be used for measuring current consumption or monitoring voltage levels to the nRF9160.

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 by connecting a power supply to connector **P28**.

For more information on measuring, see sections [Using an oscilloscope for current profile measurement](#) on page 37 and [Using a current meter for current measurement](#) on page 37.

6.1 Preparing the development kit for current measurements

To measure the current consumption of the *SiP*, you must first prepare the *DK*.

1. Remove jumper from **P24**.

Removing the jumper disconnects the nRF9160 from the power management circuitries on the *DK*.

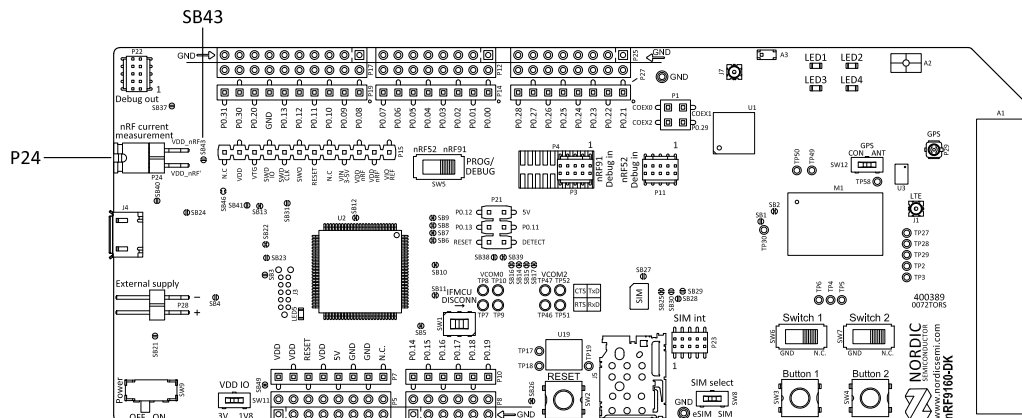


Figure 28: Solder bridge SB43 and P24 on the nRF9160 DK

2. To restore normal kit functionality after measurement, apply the jumper on **P24** or short **SB43**.

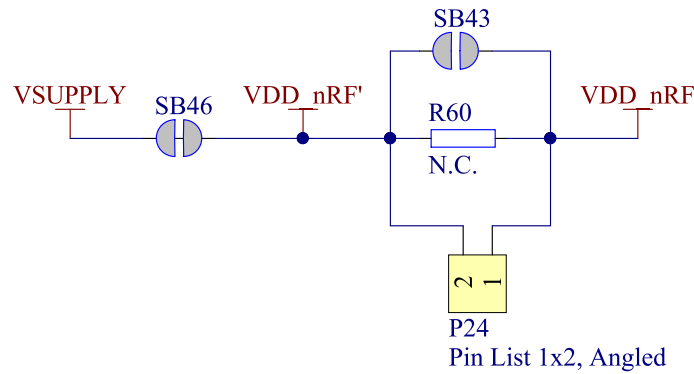


Figure 29: nRF power source

6.2 Using an oscilloscope for current profile measurement

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 section [Preparing the development kit for current measurements](#) on page 36.

Follow the steps below to measure the current profile of the nRF9160:

1. Solder a $0.5\ \Omega$ resistor to R60.

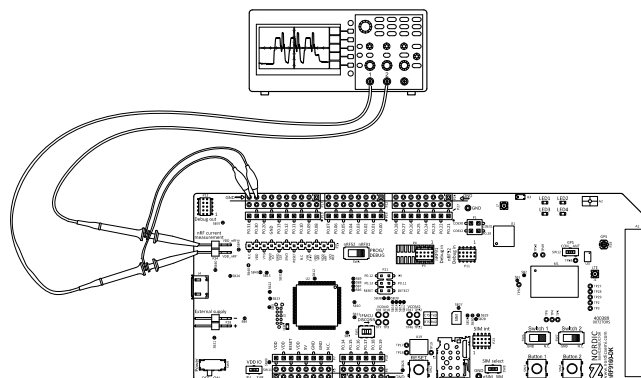


Figure 30: Current measurement with an oscilloscope

2. Connect probes to the pins on connector **P24**.
3. Measure the current power profile by measuring the voltage drop over the $0.5\ \Omega$ resistor.

6.3 Using a current meter for current measurement

The current drawn by the nRF9160 can be measured using a current meter.

Before you start, make sure you have prepared the *DK* as described in section [Preparing the development kit for current measurements](#) on page 36.

To connect the current meter in series with the nRF9160, connect the current meter to the two uppermost pins on connector **P24**.

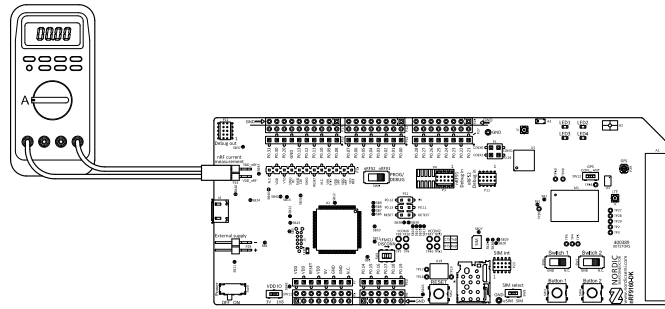


Figure 31: Current measurement with a current meter

Note: Use a high-speed, high-dynamic-range ampere meter for the best and most reliable measurements. Current range switching in the current meter may affect the power supply to the nRF9160. High speed and bandwidth is required to detect rapid changes in the current consumption in the nRF9160.

7 RF measurements

The nRF9160 DK is equipped with a small size coaxial connectors **J1** and **J7** for measuring the RF signal for LTE and 2.4 GHz.

The connectors are of 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 0.5–1 dB.

An adapter is available (Murata part no. MXHS83QE3000) 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 will disconnect the onboard antenna and connect the RF signal from the nRF9160 to the adapter.

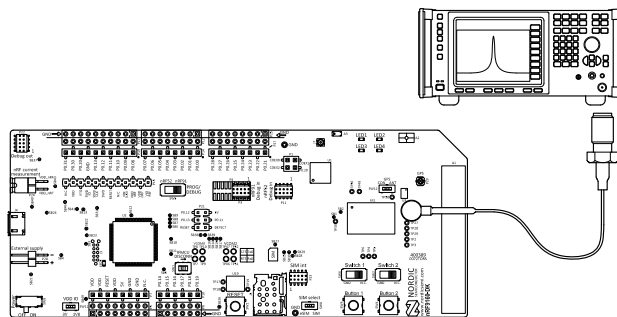


Figure 32: Connecting a spectrum analyzer

8 Radiated performance of nRF9160 DK

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

All antennas on the nRF9160 DK have fixed matching networks, which means that no matching configuration is needed to switch between the frequency bands. The average performance of the LTE antenna mounted on the nRF9160 DK is shown in the table below. The LTE antenna also supports other frequency ranges but it is not optimized for operating on these frequency bands.

Band	Average return loss [dB]	Average efficiency [%]
3	-13.5	62.0
4	-7.1	47.1
13	-8.5	58.5
20	-10.5	73.8

Table 10: Antenna performance versus radio band

The 2.4 GHz antenna on the nRF9160 DK is optimized for the frequency range of 2.4–2.48 GHz. It has an average return loss of -15 dB, average efficiency being 80 %.

Glossary

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

Narrowband Internet of Things (NB-IoT) User Equipment (UE) category with 200 kHz UE bandwidth and a single RX antenna, specified in 3GPP Release 13.

Clear to Send (CTS)

In flow control, the receiving end is ready and telling the far end to start sending.

Development Kit (DK)

A development platform used for application development.

Fast Identity Online (FIDO)

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

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 is utilizing two dedicated pins on the RS-232 connector, Request to Send and Clear to Send.

Inter-integrated Circuit (I²C)

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.

nRF Connect for 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 Connect for Cloud \(nrfcloud.com\)](https://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.

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.

System in Package (SiP)

A number of 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.

Transmit Data (TXD)

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

Acronyms and abbreviations

These acronyms and abbreviations are used in this document.

BPF

Band-Pass Filter

CTS

Clear to Send

DK

Development Kit

FIDO

Fast Identity Online

GPS

Global Positioning System

HWFC

Hardware Flow Control

I²C

Inter-integrated Circuit

LDO

Low-Dropout (Regulator)

LNA

Low-Noise Amplifier

RTS

Request to Send

RXD

Receive Data

SAW

Surface Acoustic Wave

SiP

System in Package

SoC

System on Chip

TXD

Transmit Data

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