nRF21540 EK Hardware

v1.0.0

User Guide

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NORDIC SEMICONDUCTOR

Contents

Revision history

Date	Description
2022-02-09	First release

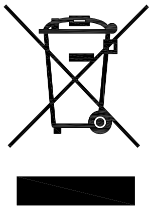
1 Introduction

The nRF21540 EK is a hardware platform used to monitor the performance of the nRF21540 RF front-end module (FEM) by connecting it to lab equipment or other radios with a *SubMiniature Version A (SMA)* connector.

The key features of the *Evaluation Kit (EK)* are:

- nRF21540 FEM for *Bluetooth*® Low Energy, Bluetooth mesh, 2.4 GHz proprietary, Thread, and Zigbee range extension
- Three SMA connectors

For access to firmware source code, hardware schematics, and layout files, see www.nordicsemi.com.



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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.

2 Kit content

The nRF21540 EK consists of hardware, access to software components, reference design files, and documentation.

The nRF21540 EK (PCA63550) comes with three *SMA* connectors.

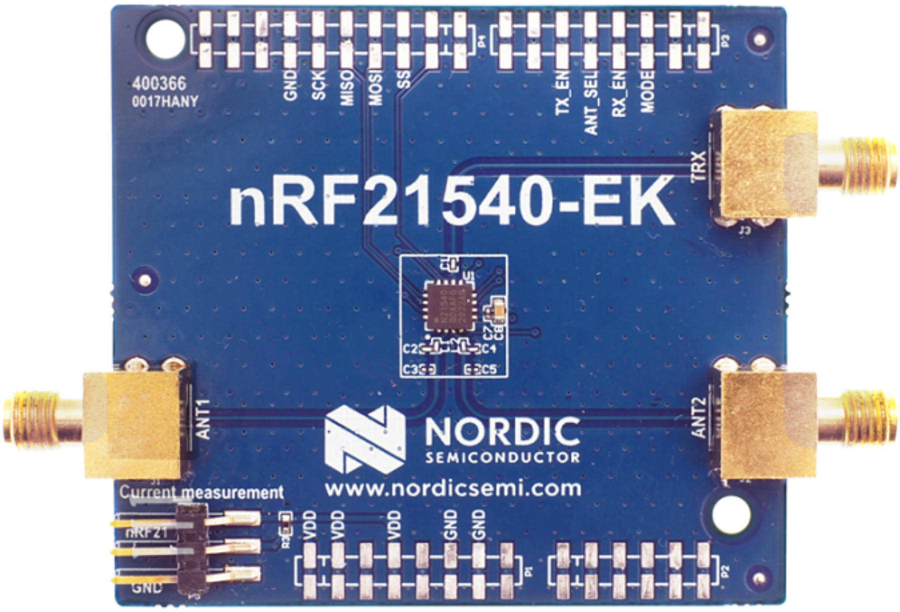

Figure 1: nRF21540 EK

Hardware files

Schematics, layout, bill of materials, and Gerber files for the nRF21540 EK are available on the product page.

3 Hardware description

The nRF21540 EK can be used for developing with the nRF21540 front-end module (FEM) and wireless *Development Kit (DK)*s. It can also be used for testing RF parameters of the nRF21540.

3.1 Hardware drawings

nRF21540 EK hardware drawings show both sides of the PCA63550.

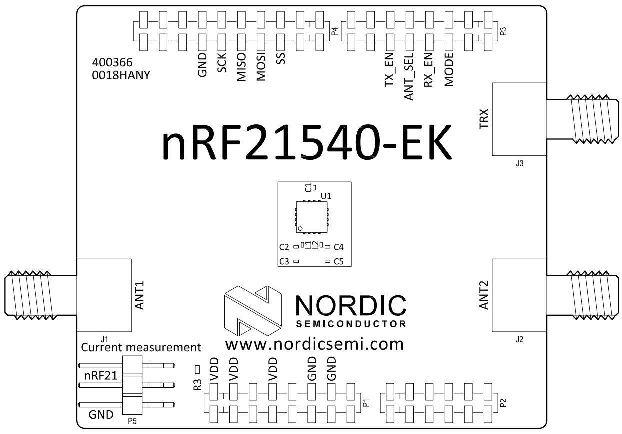

Figure 2: nRF21540 EK (PCA63550) front view

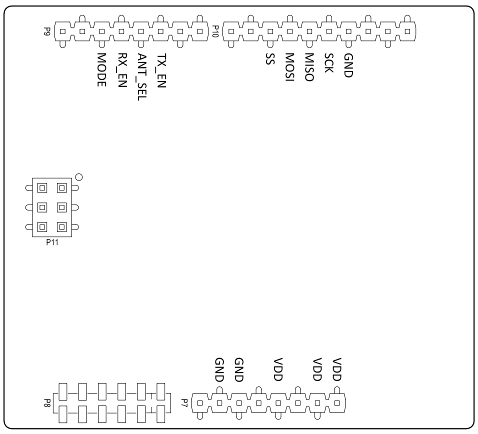

Figure 3: nRF21540 EK (PCA63550) back view

3.2 Block diagram

The block diagram shows the nRF21540 EK functional architecture.

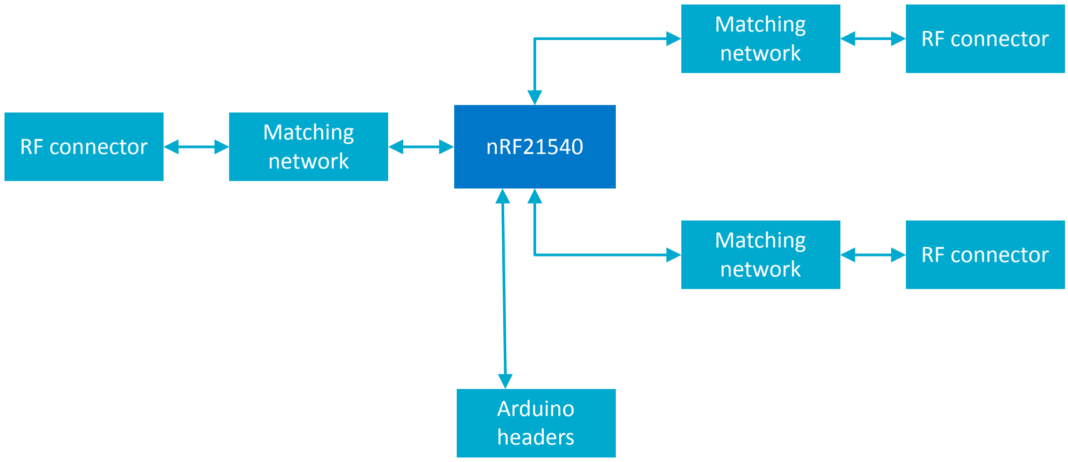

Figure 4: Block diagram

3.3 Power supply

The nRF21540 EK has multiple power options.

The power options are the following:

- VDD pins on **P5**
- VDD pins on **P7**

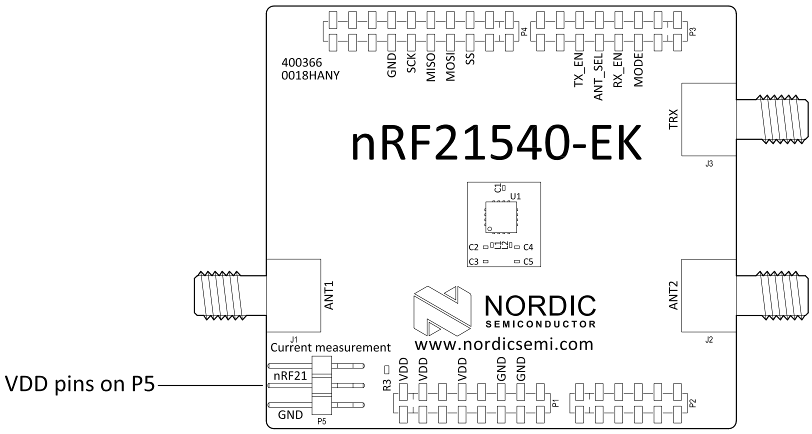

Figure 5: Power supply option P5

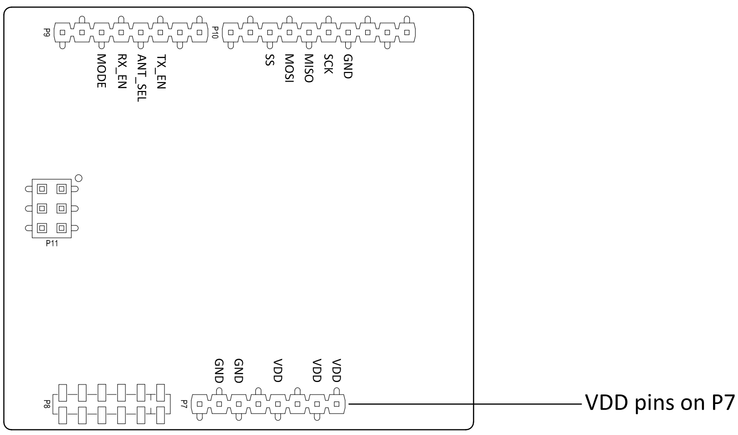

Figure 6: Power supply option P7

Power source	Voltage level
VDD	1.7 V–3.6 V (same as GPIO pin voltage)

Table 1: nRF21540 EK power source

The VDD for the nRF21540 EK must have the same voltage as the *General-Purpose Input/Output (GPIO)* pins used to control the nRF21540 through the pin control interface/SPI interface available on the Arduino headers.

Note: Nordic recommends a maximum current input of 0.5 A.

3.4 nRF21540 Front-End Module

The nRF21540 is an RF front-end module (FEM) for Bluetooth LE, Bluetooth mesh, 2.4 GHz proprietary, Thread, and Zigbee range extension.

When combined with an nRF52 or nRF53 Series *System on Chip (SoC)*, the nRF21540 RF FEM's +21 dBm TX output power and 13 dB RX gain ensure a superior link budget for up to 16x range extension.

The nRF21540's TX power is dynamically adjustable and output power can be set up to +21 dBm in small increments. This ensures that designs can run with output power within 1 dBm of the allowable range across all regions and operating conditions. The LNA has a low noise figure of 2.5 dB that ensures improved RX sensitivity.

The nRF21540 FEM has a 50Ω *SMA* input and 2x 50Ω SMA outputs. This enables connecting an SoC or a signal generator to the input. It also enables connecting the outputs to measurement tools or to antennas directly. The FEM can be configured through the pins available on the Arduino headers.

3.5 Connector interface

Access to the nRF21540 control pins is available from connectors **P7**, **P9**, and **P10**.

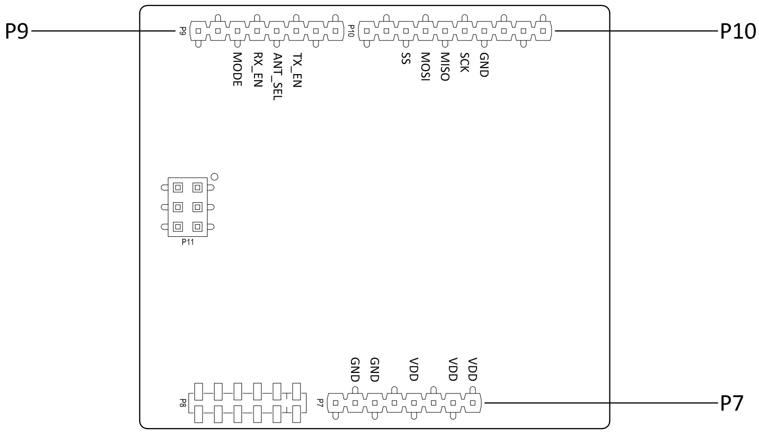

Figure 7: nRF21540 EK connectors

The **P5** connector provides access to ground and power on the nRF21540 EK.

The nRF21540 is connected to the Arduino headers using the following mapping.

GPIO	Signal	FEM function
P10.4	SPI MOSI	Serial Data In
P10.5	SPI MISO	Serial Data Out
P10.6	SPI CLK	Serial Clock
P10.3	SPI CS	Chip Select
P10.2	GPIO	Power Down
P9.3	GPIO	Mode Select
P9.4	GPIO	RX Enable
P9.5	GPIO	Antenna Select
P9.6	GPIO	TX Enable

Table 2: FEM to header connection

To measure current to nRF21540, you need to remove R3 and connect an ammeter between pins 1 and 2 on P5.

4 Measuring current

The current drawn by the nRF21540 FEM can be monitored on the nRF21540 EK.

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

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

Power analyzer and Power Profiler Kit measurements are not described in this document. For more information on Power Profiler Kit, see Power Profiler Kit User Guide.

For measuring instructions, see Using an oscilloscope for current profile measurement on page 11 and Using an ampere meter for current measurement on page 12.

The nRF21540 FEM has a single VDD (1.7–3.6V) supply. The nRF21540 EK is prepared for measuring current on this domain. See the following table for the corresponding components.

Component	VDD
Measurement connector	P5
Series resistor	R3

Table 3: Components for current measurement on VDD

> **Note:** It is not recommended to use a *Universal Serial Bus (USB)* connector to power the system during current measurements. USB ports typically have significant noise that might impact measurement accuracy.

For more information on current measurement, see the Current measurement guide tutorial.

4.1 Preparing the evaluation kit

To measure current, you must first prepare the *EK*.

The suggested configurations split the power domains for the nRF21540 FEM and the rest of the EK.

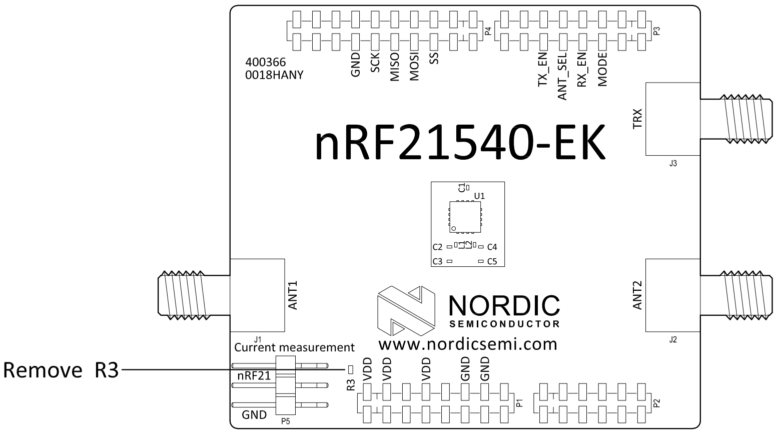

Figure 8: Preparing the EK for current measurements

- To enable current measurement, remove **R3**.
- To restore normal kit function after measurement, solder a 0 Ω resistor on **R3** or apply a jumper between pin 1 and 2 on **P5**.

4.2 Using an oscilloscope for current profile measurement

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

Make sure you have prepared the *EK* as described in Preparing the evaluation kit on page 10.

1. Mount a 1 Ω resistor on the footprint for **R3**.
2. Connect an oscilloscope in differential mode or similar with two probes on pins 1 and 2 of the **P5** connector as shown in the following figure.
3. Calculate or plot the instantaneous current from the voltage drop across the 1 Ω resistor by taking the difference of the voltages measured on the two probes. The voltage drop is proportional to the current. The 1 Ω resistor causes a 1 mV drop for each 1 mA drawn by the circuit being measured.

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.

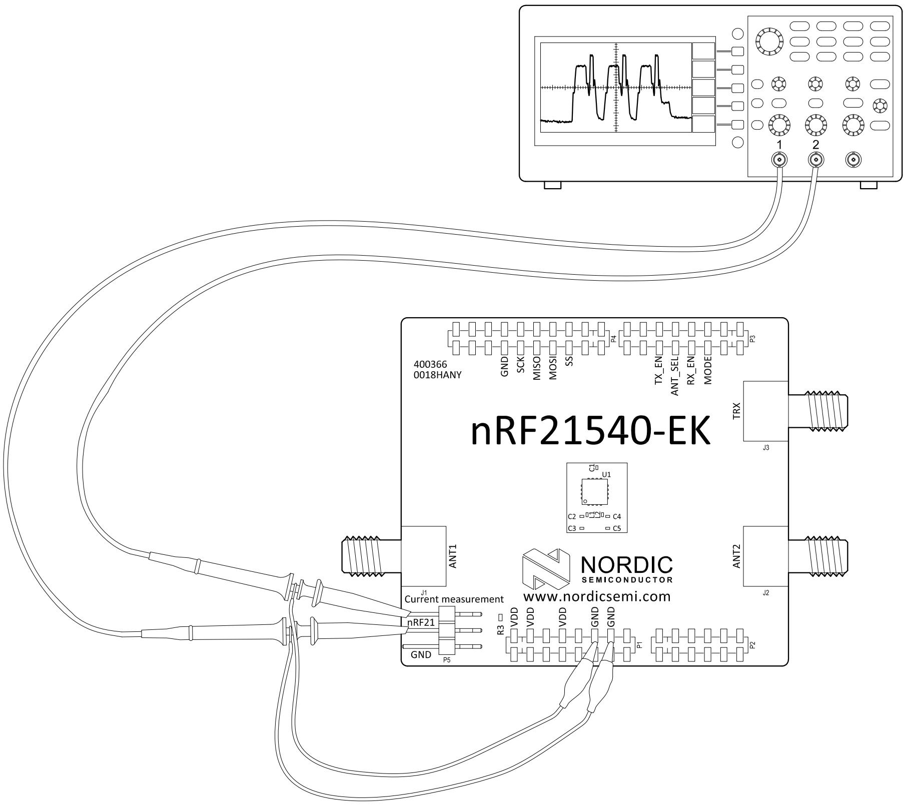

Figure 9: Current measurement with an oscilloscope

Some tips to reduce noise:

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

Use a minimum of 200 kSa/s (one sample every 5 µs) to get the correct average current measurement.

4.3 Using an ampere meter for current measurement

The average current drawn by the nRF21540 FEM can be measured using an ampere meter. This method monitors the current in series with the nRF device.

Make sure you have prepared the *EK* as described in Preparing the evaluation kit on page 10.

Connect an ampere meter between pins 1 and 2 of connector **P5** as shown in the following figure.

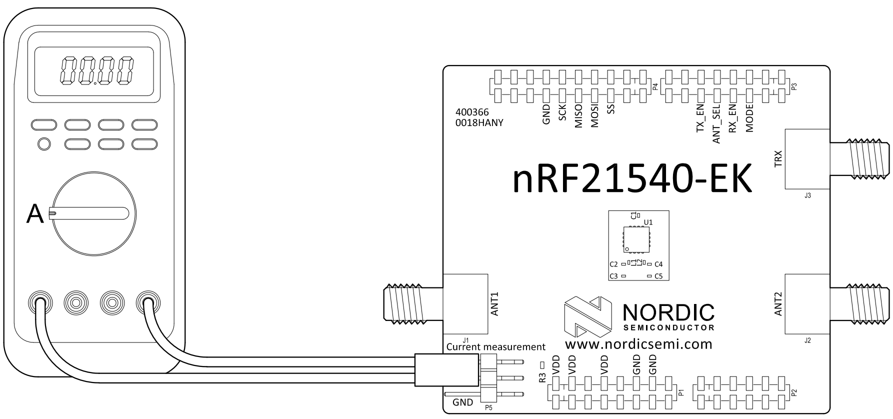

Figure 10: Current measurement with an ampere meter

Note: An ampere meter measures the average current drawn by the nRF21540 FEM if the following conditions are true:

- The FEM is in a state where it draws a constant current, or, the activity on the device changing load current, like Bluetooth LE connection events, is repeated continuously and has a short cycle time (less than 100 ms) so that the ampere meter averages whole load cycles and not parts of the cycle.
- The dynamic range of the ampere meter is wide enough to give accurate measurements from 1 µA to 150 mA.

We recommended that you use a true *Root Mean Square (RMS)* ampere meter.

5 RF measurements

The nRF21540 EK is equipped with *SMA* connectors for easy connection to laboratory equipment.

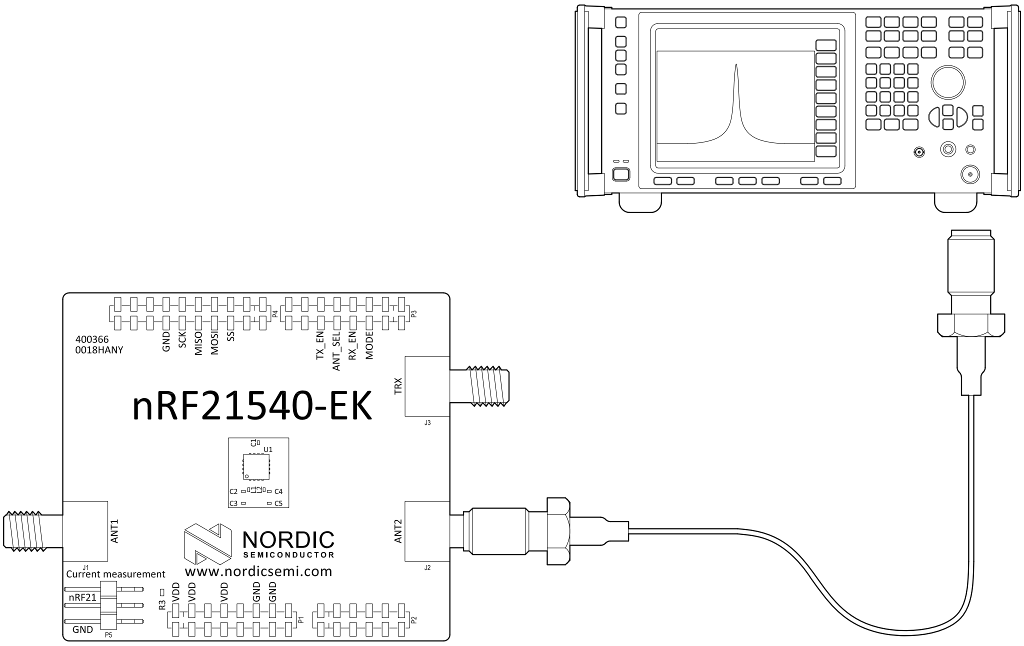

Figure 11: Connecting a spectrum analyzer

When measuring, consider that the connector and test probe adds loss to the RF signal. See the following table for more information.

Frequency (MHz)	Loss (dB)
2440	1.0
4880	1.7
7320	2.6

Table 4: Typical loss in connector and test probe

Glossary

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

Evaluation Kit (EK)
: A platform used to evaluate different development platforms.

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.

Root Mean Square (RMS)
: An RMS meter calculates the equivalent Direct Current (DC) value of an Alternating Current (AC) waveform. A true RMS meter can accurately measure both pure waves and the more complex nonsinusoidal waves.

SubMiniature Version A (SMA)
: A semi-precision coaxial RF connector for coaxial cables with a screw-type coupling mechanism.

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.

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 may need to consult other documents.

Nordic documentation

- nRF21540 product page
- nRF21540 Product Specification
- nRF21540 Errata
- nRF21540 DK Hardware User Guide
- nRF Connect SDK

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