

Power Profiler Kit

User Guide

v1.0

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Revision history

Table 1: Revision history

Date	Version	Description
October 2016	1.0	First release

Chapter 1
Power Profiler Kit content and key features

The Power Profiler Kit (PPK) is an affordable and flexible tool to obtain real-time power consumption measurements on your designs.

The PPK measures current consumption for a connected nRF5x Development Kit or any external board. It can measure current from 1 uA up to 70 mA and give a detailed picture of the current profile for the user application.

The PPK can be used in conjunction with the nRF5x DK to measure current on the nRF5x DK or on an external board. The hardware is delivered with a desktop application developed in the Python programming language which makes customization possible. Several measurement configurations are offered which are described in this user guide.

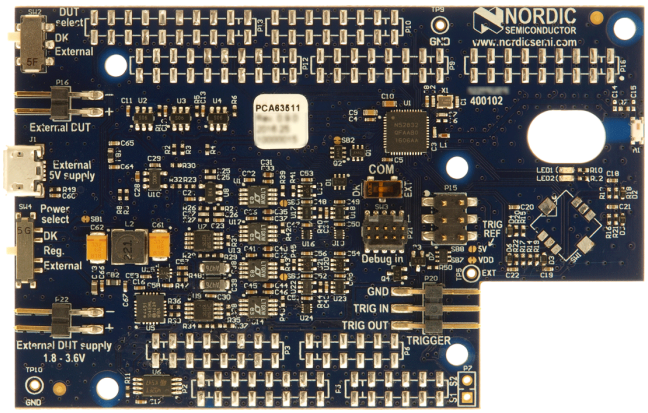


Figure 1: PPK content - the PPK board (PCA63511)

PPK content

- The PPK board PCA63511
- Downloadable package:
  - Software package (ZIP) that contains:
    - Python software for computer (.py)
    - Firmware package for PCA63511 (.HEX)
  - Hardware package (ZIP) that contains schematic, layout, and BOM for PCA63511
- This user guide

Key features

- Variable power supply voltage ranging from 1.8 V to 3.6 V (software configurable)
- Maximum 70 mA current measurement
- Down to 0.2 µA resolution current measurement
- Three current measurement ranges with automatic switches that ensure optimal measurement resolution throughout the whole measurement range
- Measurement accuracy better than +/-20 % (average currents measurement)
- Desktop application displaying current measurement analysis

- Real-time current measurement display
- Long recording display, up to 20 seconds
- Real-time display, down to 15 µs resolution
- Internal/external trigger
- Screen data export

Applications

- Quick power consumption measurements on a firmware running on an nRF5x DK
- Quick power consumption measurements on a firmware running on an external board
- Accumulative measurements, such as average, peak, minimum, maximum
- Instantaneous measurements presented as waveform plots

Computer requirements

To run the PPK, connect it to a USB port of a computer.

Supported operating systems

The supported operating systems are:

- Microsoft Windows 7/8/10

  Important:

  The PPK desktop application is developed using Python, which works on a number of platforms. However, it is recommended to use the PPK only with Microsoft Windows, as the tool has not been tested on other platforms.

Chapter 2
Quick start

Your Power Profiler Kit (PPK) can be up and running in just a few steps.

In the simplest configuration, the PPK is connected to an nRF5x Development Kit (DK), which is not included in the present package. Configure the PPK for current measurements as described in Configuring the Power Profiler Kit on page 14, and upload the firmware for your application to the nRF5x DK before performing the quick start. The current measurements are performed on the nRF5x DK device. The nRF5x DK is also used for sending data to the PPK desktop application and as a power supply.

See Nordic Semiconductor Infocenter for information on the nRF51 Series and nRF52 Series.

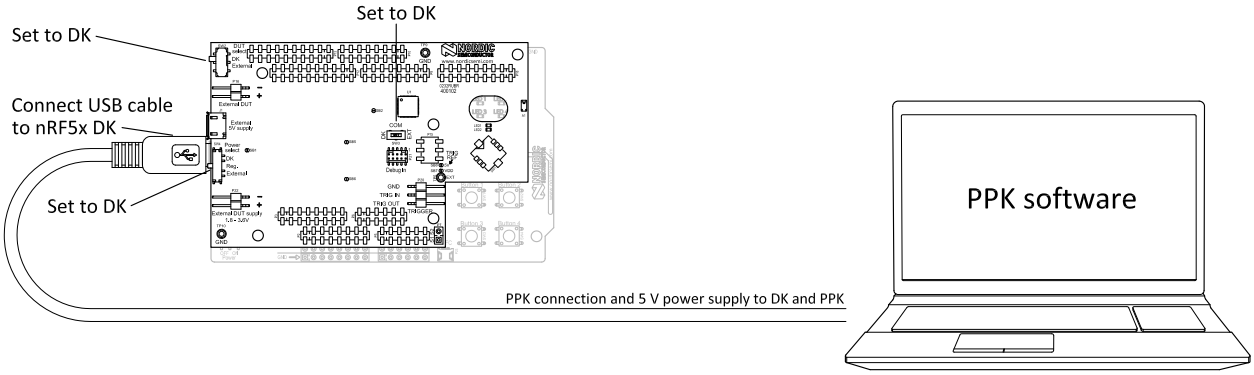


Figure 2: Typical configuration for current measurements on the nRF5x DK

Complete the following steps:

> **Important:** In some of the procedure descriptions, the nRF52 DK is used as a reference, but the nRF51 DK can also be used.

1. If the PPK is used with the nRF5x DK, prepare the nRF5x DK for power measurements by cutting the PCB track shorting solder bridge **SB9** according to Preparing the development kit board. Do not short the solder bridge **SB11**/**SB12**.
2. Connect the PPK into the nRF5x DK as shown in the following figure.

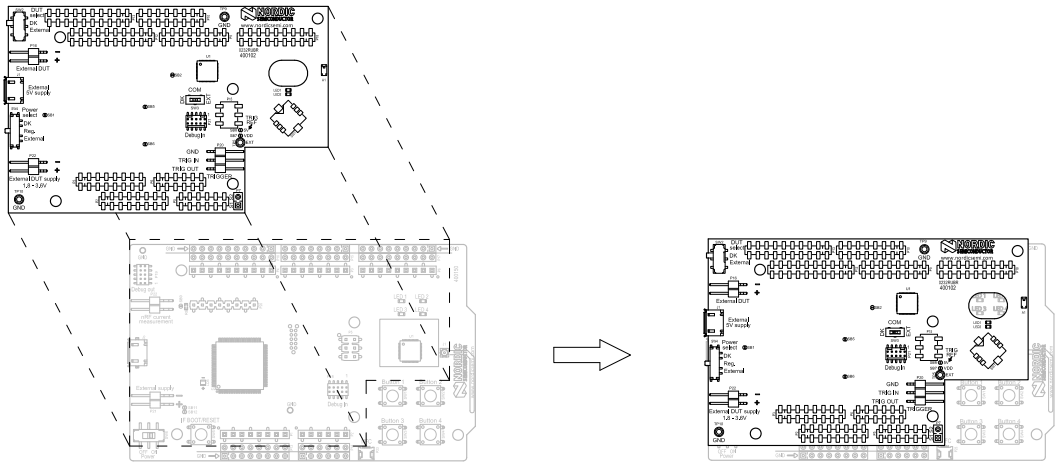


Figure 3: Connecting the PPK into the nRF5x DK

3. Install the PPK software as described in Installing the Power Profiler Kit software package on page 13.

4. Start the PPK desktop application as described in Using the Power Profiler Kit desktop application on page 21.

You are ready to perform measurements with the PPK.

For firmware upgrade, see Upgrading the firmware on page 26.

Chapter 3
The Power Profiler Kit overview

The Power Profiler Kit (PPK) contains both hardware and software components. It offers a current measurement functionality through several configuration setups.

The following subsections provide an overview of the measurement system and PPK components, such as connectors and switches.

For information about the various configuration setups, see Configuring the Power Profiler Kit on page 14.

For information about the configuration settings and options for the PPK desktop application, see:

- Configuration settings on page 22
- Options for the Plots window on page 24

For electrical specifications, see Electrical specifications.

3.1 The measurement system

The main part of the PPK is the nRF52832 SoC, which uses its ADC (analog-to-digital converter) to measure the voltage drop over resistors. Resistor values are used to calculate the current consumption. The PPK has three different measurement ranges, and the switching between them is done automatically through an automatic switch circuitry.

To send the data to the desktop application, the nRF52832 SoC on the PPK uses the SEGGER RTT (Real Time Transfer). By connecting the PPK to an nRF5x DK, the SEGGER available on the nRF5x DK can be used for the computer connection. Alternatively, an external SEGGER J-Link can be used.

Block diagram

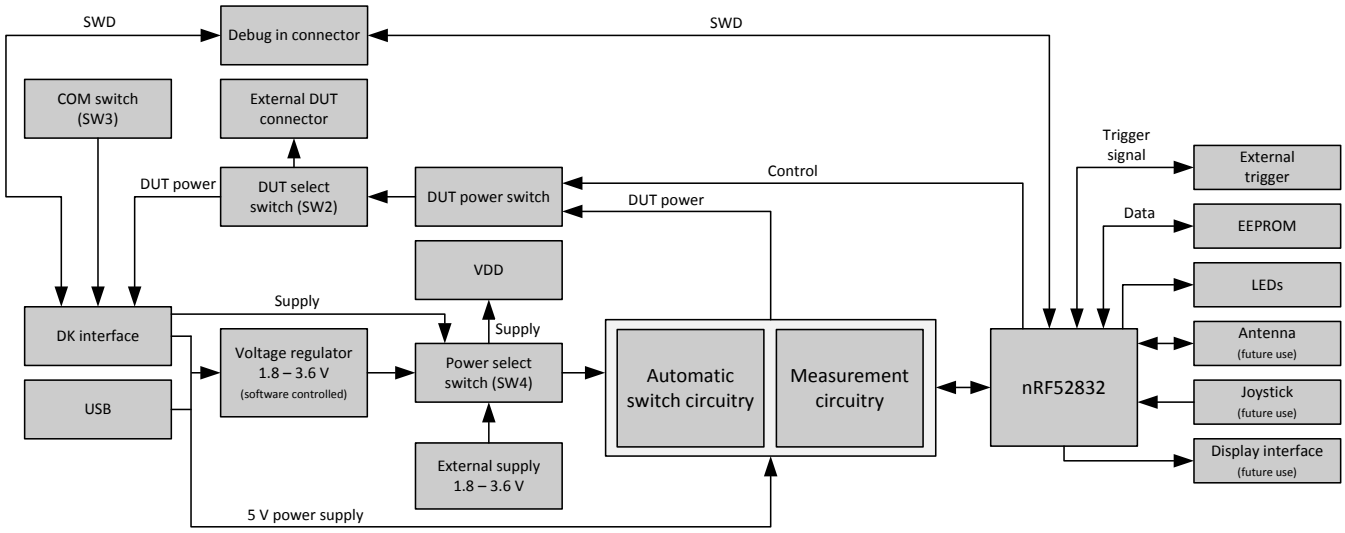


Figure 4: The block diagram for the PPK

Power supply

For the digital logic of the PPK and for the device under test (DUT) supply there are three power supply options:

- DK interface
- PPK on-board voltage regulator
- External supply

The power supply is selected by the power select switch (SW4).

The PPK on-board voltage regulator is supplied by the 5 V USB power supply. Its output can be adjusted between 1.8 V and 3.6 V by the nRF52832 through the PPK desktop application.

If an external power supply is used, the voltage is applied directly to the circuits without regulation. This voltage must be limited to the 1.8 - 3.6 V range.

When the DK is selected as the power supply, the DK supplies the PPK circuitry.

The analog part of the automatic switch circuitry requires a 5 V power supply. When the PPK is connected to an nRF5x DK, the 5 V is supplied by the DK. When the PPK is used standalone, a USB cable has to be connected to supply the 5 V required by the circuitry.

Measurement ranges and switching points

In order to have high measurement dynamic range, the PPK features three calibrated parallel measurement means realizing the three measurement ranges simultaneously. An automatic range switching mechanism always selects the correct measurement range depending on the instantaneous current draws by the DUT.

If your DUT has a current consumption that is close to a switching point, it will cause rapid switching up and down between the ranges and create measurement errors and distorted plots. A hysteresis is applied at the switching point in order to avoid distorted measurements as shown in Figure 5: Measurement ranges and switching points on page 9.

There are four switching points:

- **Switch up LO**: Switches up from low to medium range
- **Switch up HI**: Switches up from medium to high range
- **Switch down HI**: Switches down from high to medium range
- **Switch down LO**: Switches down from medium to low range

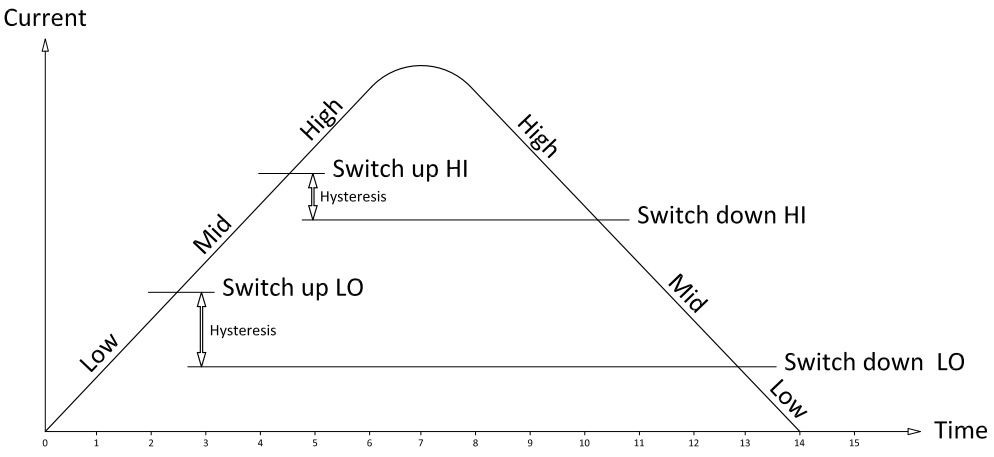


Figure 5: Measurement ranges and switching points

DUT output

The PPK supports two modes of operation:

- Current measurements on the nRF5x DK device
- Power supply and current measurements on an external board

The DUT can be turned on and off with a power switch controlled from the PPK desktop application.

EEPROM

On the PPK, there is an EEPROM memory connected to the nRF52832 SoC. EEPROM is used to store calibration data.

Display interface and joystick

Reserved for future use.

3.2 The Power Profiler Kit connectors

Access to the PPK is available from a set of connectors.

The PPK has five connectors on the top side:

- Two connectors for the power supply: one for external DUT to provide precise control of the voltage and one for the USB
- One for connecting the custom/external hardware
- One for connecting an external trigger
- One connector for connecting an external SEGGER J-Link

The connectors on the bottom side are for connecting the PPK to an nRF5x DK, which supplies both data interface and power to the PPK.

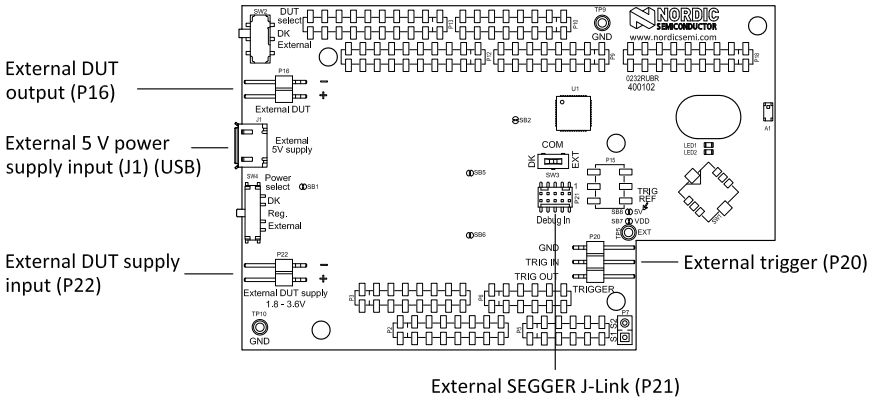


Figure 6: The PPK connectors

Table 2: The PPK connectors

Connector	Description
External 5 V power supply input (**J1**) (USB)	This USB connector on the PPK supplies the on-board analog measurement circuitry and the on-board regulator with 5 V provided by a USB host. This connector is used when the PPK is used standalone or any time the USB on the nRF5x DK is not connected. **Important:** When used with an nRF5x DK with USB connection, this connector must not be used.
External DUT output (**P16**)	The External DUT connector provides power to the DUT.

Connector	Description
External DUT supply input (**P22**)	A lab power supply from 1.8 to 3.6 V can be connected here to provide precise control of the voltage.
External trigger (**P20**)	This connector allows you to: • Feed an external trigger to the PPK (15 V max) • Have the PPK to send a trigger signal to external instruments The voltage of the TRIG OUT pin can be configured by the TRIG REF on the PPK board which has the following options: • VDD: default • 5 V: cut SB7 and solder SB8 • External voltage: cut SB7 and SB8 (if shorted) and connect to TP5 (EXT)
External SEGGER J-Link (**P21**)	Used to connect an external SEGGER J-Link for communicating with the desktop application when: • The PPK is used standalone • The SEGGER J-Link on the nRF5x DK is used for debugging of the nRF5x chip on the DK If this connector is in use and the PPK is connected to an nRF5x DK board, the COM switch must be in the "EXT" position. This is done to disconnect the PPK from the SEGGER J-Link on the DK. How to connect and use is described in detail in the following sections.

3.3 The Power Profiler Kit switches

The Power Profiler Kit (PPK) has three switches that are used to select the DUT on which the measurements are performed, power supply, and SEGGER J-Link connection respectively.

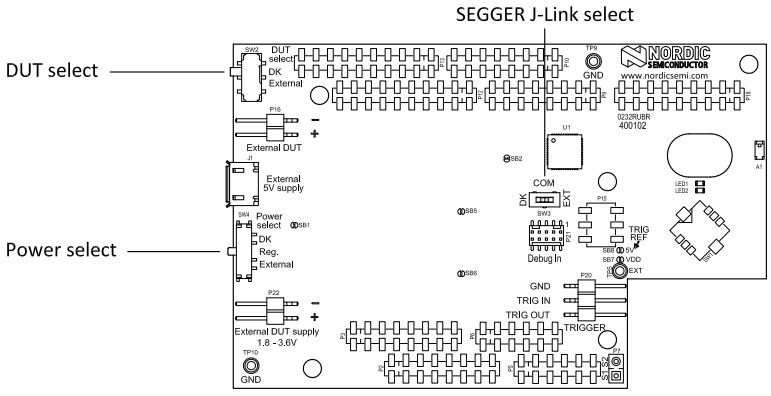


Figure 7: The PPK switches

Table 3: The PPK switches

Switch	Description
DUT select (**SW2**)	Used to define whether the measurements are performed on the nRF5x DK or on an external/custom hardware. Options:

Switch	Description
	• **DK**: The measurements are performed on the nRF5x DK. • **External**: The measurements are performed on the external/custom hardware connected to the External DUT (**P16**) connector.
Power select (**SW4**)	Used to select the power source for the PPK and DUT. Options: • **DK**: Select this option if the power source is the nRF5x DK. Used when performing measurements on the nRF5x DK (that is, when the DUT select switch is in the "DK" position). • **Reg.**: Select this option if the power source is the on-board regulator powering the PPK and the external DUT. Used when performing measurements on the external/custom hardware (that is, when the DUT select (**SW2**) switch is in the "External" position). • **External**: Select this option if an external power supply is the power source connected to the External DUT supply (**P22**) connector of the PPK. **Important:** The PPK desktop application can be used to adjust the power supply voltage only when the Power select (**SW4**) switch is in the "Reg" position, that is, when the power is supplied by the PPK on-board regulator. **Important:** If you need to use the PPK on-board regulator (the Power select (**SW4**) switch in the "Reg" position) when performing measurements on the nRF5x DK, note that it is not recommended unless the PPK on-board regulator voltage exactly matches the nRF5x DK voltage. Even a small mismatch between the two will influence the current measurements due to current leakage and result in erroneous measurement or hardware damage. The voltage is usually somewhere between 2.9 and 3 V. To be sure, it is recommended to measure the DK voltage. This configuration, although possible, is not recommended.
COM (**SW3**)	This switch is used to select the SEGGER J-Link connection. Options: • **DK**: The SEGGER J-Link on the nRF5x DK kit is used. • **EXT**: An external SEGGER J-Link is used and connected to the Debug in (**P21**) connector. This will disconnect the PPK from the SEGGER J-Link on the nRF5x DK. **Important:** To program the DUT on the DK, the switch must be in the "EXT" position. When programming with the switch in the "DK" position, the PPK will be programmed. **Important:** When the PPK uses the nRF5x DK SEGGER J-Link, it cannot be used to debug the nRF5x SoC on the DK at the same time. To debug the nRF5x DK SoC on the DK, set the COM (**SW3**) switch in the “EXT” position.

Chapter 4
Installing the Power Profiler Kit software package

This section describes the installation procedure for the Power Profiler Kit (PPK) software package. Python 2.7.12 environment, SEGGER J-Link and the nRF5x Command Line Tools for Microsoft Windows are required before the PPK software package is installed.

To install the PPK software package, complete the following steps:

1. Install the prerequisite tools:
   a) Download and install the Python 2.7.12 environment from python.org.

      Important:

      - Select the 32-bit Microsoft Windows x86 Installer (MSI).
      - Make sure to select the option to add Python to path during the installation.

   b) Download and install the SEGGER J-Link driver from the **Downloads** section (tab) of the nRF52 DK package in nRF52 Development Kit.

      Alternatively, the SEGGER J-Link driver can be downloaded from SEGGER J-Link Software.

   c) Download and install the nRF5x Command Line Tools for Microsoft Windows from nRF5x Tools Windows32.
2. Download the PPK software package from http://www.nordicsemi.com/Products/Power-Profiler-Kit.

   The file format is `PPK_SW_vX_X_X_X_X.zip`, where X sets the revision history.

   Important: The latest version is always available from the link provided above.
3. Unzip the software package to a directory of your choice on your computer.
4. Navigate to and run the file `python_packages.bat`.

   This will install the following:

   - pyside
   - pyqtgraph
   - numpy
   - pynrfjprog
   - future

   Important: The software will not run before a PPK board is connected to the computer as described in the following chapter.

Chapter 5
Configuring the Power Profiler Kit

This section describes four different configuration setups for the Power Profiler Kit (PPK) and methods for current measurement.

To configure the PPK, complete the following steps:

1. For measurement accuracy, some adjustments are needed. For details, see Measurement accuracy optimization on page 14.
2. Choose a use case and implement a configuration for the PPK. The options are presented in the following table.

Table 4: The PPK use cases

Use case	Configuration setup/measurement method
Design stage, no custom hardware	Current measurements on the nRF5x DK on page 15.
Design and optimization stage, no custom hardware, with debugging	Current measurements on the nRF5x DK while debugging on page 16.
Design stage, using external/ custom hardware	Current measurements on a custom hardware with nRF5x DK on page 16.
	Current measurements on a custom hardware without using an nRF5x DK on page 18.

5.1 Measurement accuracy optimization

When measuring current with the PPK, some adjustments are needed to optimize the measurement accuracy. The nRF5x DK must be prepared for the power measurement.

Match voltages between the nRF5x DK and the Power Profiler Kit

In cases where the PPK is used with an nRF5x DK, it is recommended to use the Power select (**SW4**) switch in the "DK" position.

Although not recommended, if you need to use the PPK on-board regulator as the power source due to noise issues (to improve the USB noise filtering), make sure that the PPK regulator voltage exactly matches the nRF5x DK voltage. Otherwise, current leakage may occur and lead to erroneous current readings.

Considerations when measuring on external DUTs

When measuring current on external devices, it is important to keep in mind that large filtering capacitors which may be present on the DUT circuit will smooth out the variations in current consumption. This yields a good result for the average current consumption, but the short current bursts will be filtered out and the plot might differ from what you see on the measurements done on the nRF5x DK during development.

As a good practice, keep extra decoupling capacitors to a minimum when measuring detailed current draw. Decoupling capacitors to ensure correct operation of the devices must be included though.

5.2 Connecting the Power Profiler Kit to the nRF5x DK

For all of the PPK configurations, except when the PPK is running standalone, the PPK needs to be connected to the nRF5x Development Kit.

Connect your PPK to the nRF5x DK as shown in the following figure.

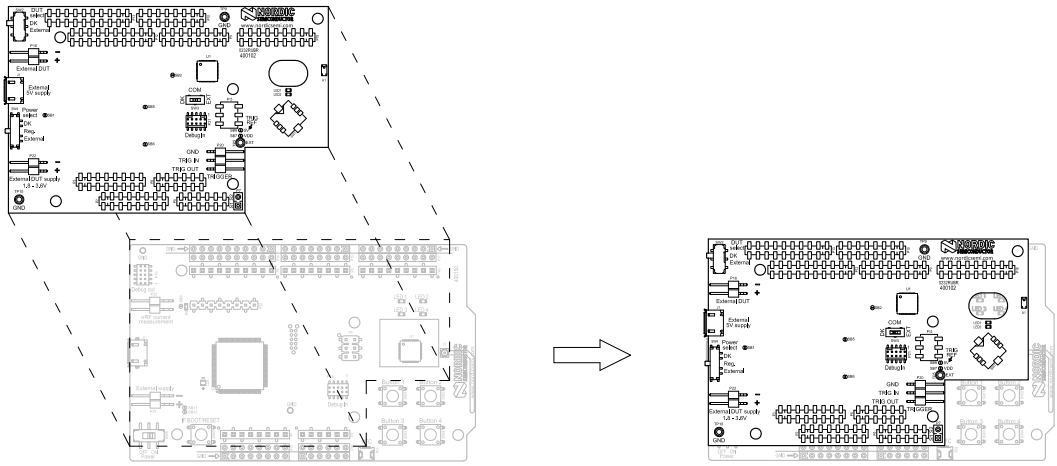


Figure 8: Connecting the PPK to the nRF5x DK

5.3 Current measurements on the nRF5x DK

The purpose of this setup is to be used at a design stage where custom hardware is not available yet.

This is a typical configuration for the PPK which allows quick setup and measurements in reference applications from the SDK or in custom applications.

In this case, the connection to the PPK desktop application is provided by the SEGGER J-Link on the nRF5x DK with a power supply applied on the DK. The configuration for this use case is shown in the following figure.

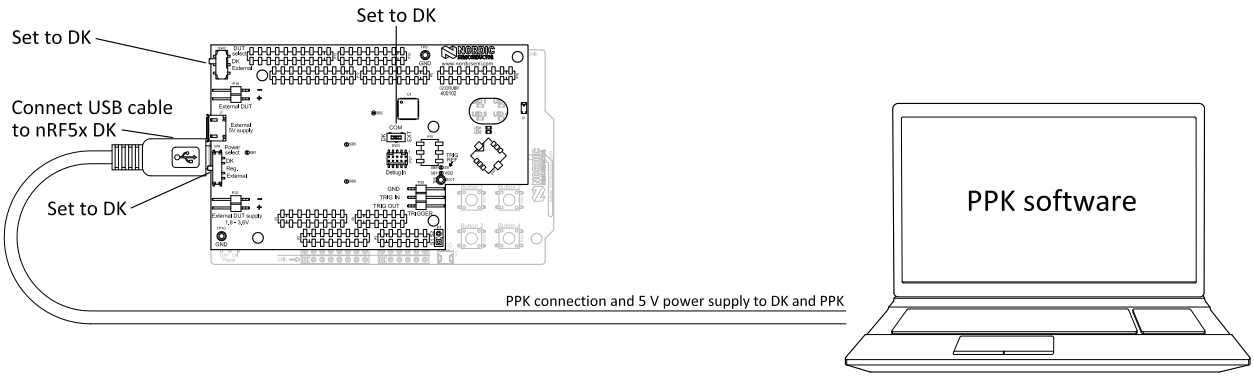


Figure 9: Current measurements on the nRF5x DK

Make sure that the following are configured:

- The PPK board (PCA63511) is connected to the nRF5x DK board as described in Connecting the Power Profiler Kit to the nRF5x DK on page 15.
- The DUT select (**SW2**) switch is in the "DK" position.
- The Power select (**SW4**) switch is in the "DK" position.
- The COM (**SW3**) switch is in the "DK" position.

- The USB cable is inserted into the USB on the nRF5x DK and connected to a computer with the PPK desktop application.

5.4 Current measurements on the nRF5x DK while debugging

The purpose of this setup is to be used at a design and optimization stage where no custom hardware is available yet. The SEGGER J-Link debugger on the nRF5x DK is used for debugging.

As the SEGGER J-Link of the nRF5x DK is used for debugging, an additional SEGGER J-Link is needed for connection to the computer and the PPK desktop application. This could be either another nRF5x DK SEGGER J-Link or a standalone SEGGER J-Link which can be purchased separately from SEGGER J-Link Software.

The configuration for this use case is shown in the following figure.

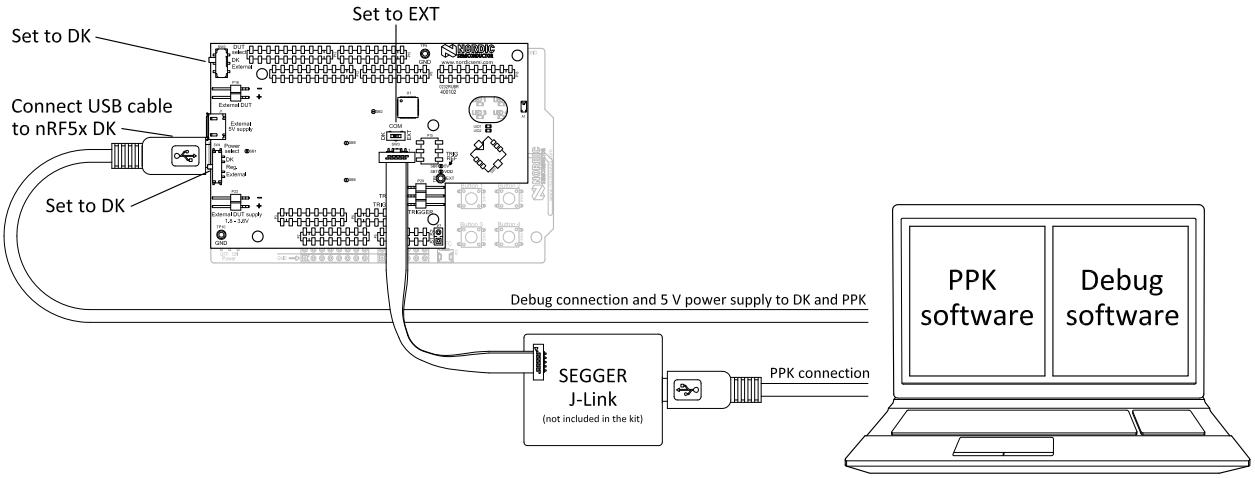


Figure 10: Current measurements on the nRF5x DK with debugging

Make sure that the following are configured:

- The PPK board (PCA63511) is connected to the nRF5x DK board as described in Connecting the Power Profiler Kit to the nRF5x DK on page 15.
- The DUT select (**SW2**) switch is in the "DK" position.
- The Power select (**SW4**) switch is in the "DK" position.
- The USB cable is inserted into the USB on the nRF5x DK and connected to a computer running the debugging software.
- The additional SEGGER J-Link is connected to the Debug in (**P21**) connector on the PPK, using the 10-pin flat cable. The USB cable is inserted into the SEGGER J-Link and connected to a computer running the PPK desktop application.
- The COM (**SW3**) switch is in the "EXT" position.

  Important: Power consumption may be higher for devices during debugging than in normal operation. The difference depends on what is active at any given time. This is caused by the clocking of the debug interface and constantly powering sections of the device that are independent of the operation of the part. When debugging, accurate power consumption cannot be measured, but software issues can be detected.

5.5 Current measurements on a custom hardware with nRF5x DK

The purpose of this setup is to be used at a design stage on a custom hardware with the nRF5x DK.

In this use case, the PPK measures the current on the custom hardware (DUT). The PPK is connected to the nRF5x DK which is used as a SEGGER J-Link interface to the computer running the PPK desktop application.

The power supply is provided either by the PPK on-board regulator or an external power source.

The power supply is applied to the nRF5x DK, which in turn powers the PPK board. This is used to supply power to the on-board analog measurement circuitry and the on-board regulator with 5 V. This will supply the custom hardware (DUT) when using the on-board regulator. If an external power source is used to supply the custom hardware, the USB connection will still be needed to supply the measurement circuitry of the PPK as well as for communication with the computer.

The following two figures show the configuration for this use case: one with the PPK on-board regulator as the power source and one with an external power source.

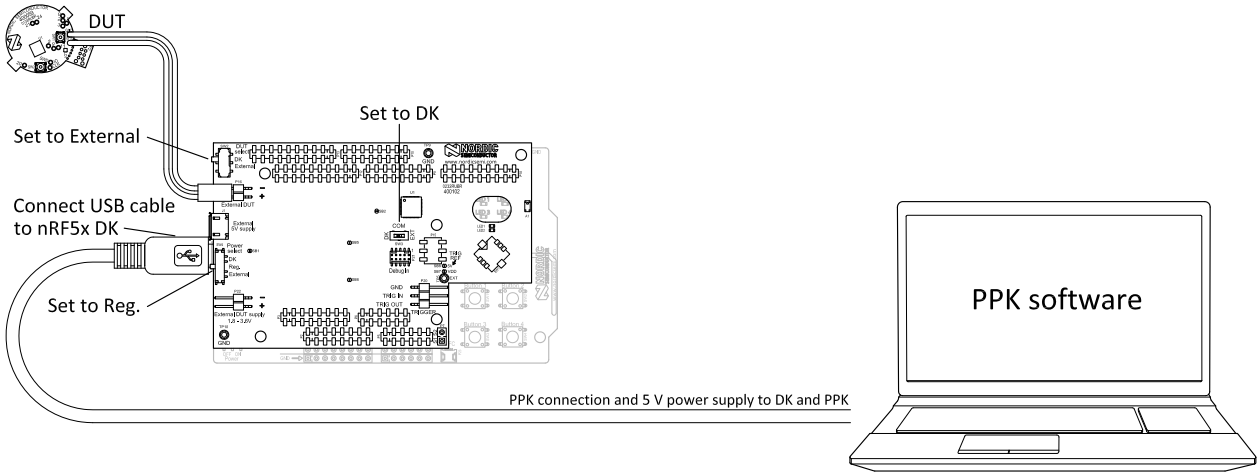


Figure 11: Current measurements on custom hardware with the on-board regulator as the power source and the nRF5x DK

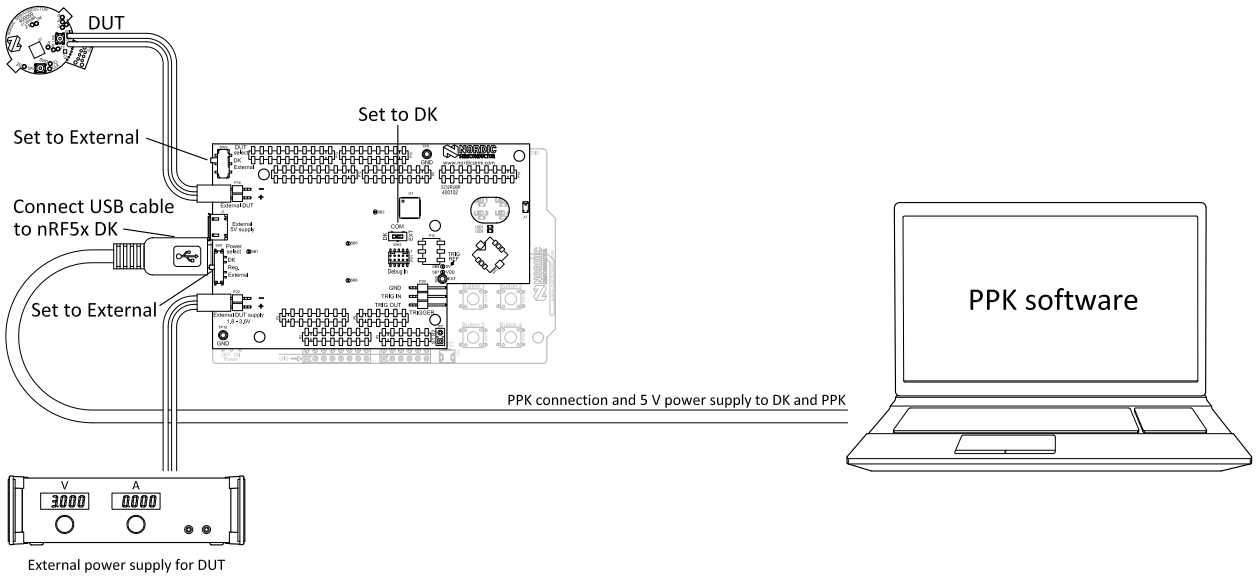


Figure 12: Current measurements on custom hardware with an external power source and the nRF5x DK

Make sure that the following are configured:

- The PPK board (PCA63511) is connected to the nRF5x DK board as described in Connecting the Power Profiler Kit to the nRF5x DK on page 15.
- The USB cable is inserted into the USB connector on the nRF5x DK and connected to a computer running the PPK desktop application.
- The DUT select (**SW2**) switch is in the "External" position.

- The custom hardware (DUT) is connected to the External DUT (**P16**) connector of the PPK.
- The power source is one of the following:
  - The PPK on-board regulator: Set the Power select (**SW4**) switch in the "Reg" position.
  - External power supply: In addition to the USB cable inserted in the nRF5x DK, make sure that the external power is connected to the External DUT supply **(P22)** connector of the PPK (voltage range from 1.8 to 3.6 V). Set the Power select (**SW4**) switch in the "External" position.
- The COM (**SW3**) switch is in the "DK" position.

5.6 Current measurements on a custom hardware without using an nRF5x DK

The purpose of this setup is to be used at a design stage on a custom hardware without using the nRF5x DK.

The power supply is provided either by the PPK on-board regulator or an external power source.

The External 5V supply (**J1**) USB connector of the PPK is used to supply power to the on-board analog measurement circuitry and the on-board regulator with 5 V. This will supply the custom hardware (DUT). If an external power source is used to supply the custom hardware, the USB connection will still be needed to supply the measurement circuitry of the PPK.

The following two figures show the configuration for this use case: one with the PPK on-board regulator as the power source and one with an external power source.

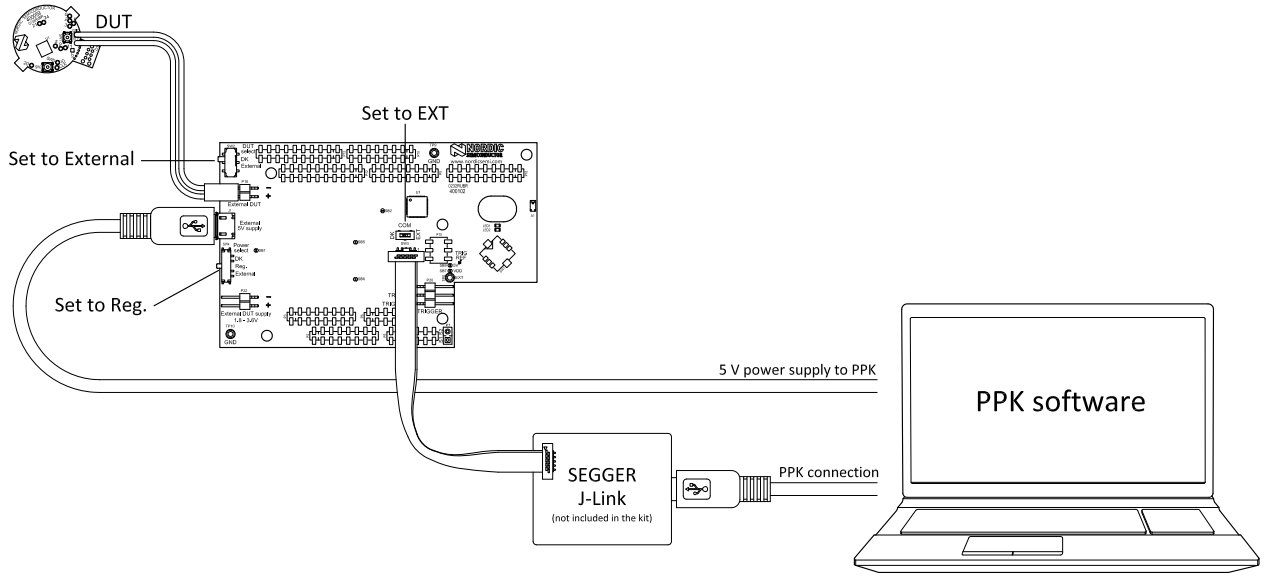


Figure 13: Current measurements standalone with the on-board regulator as the power source

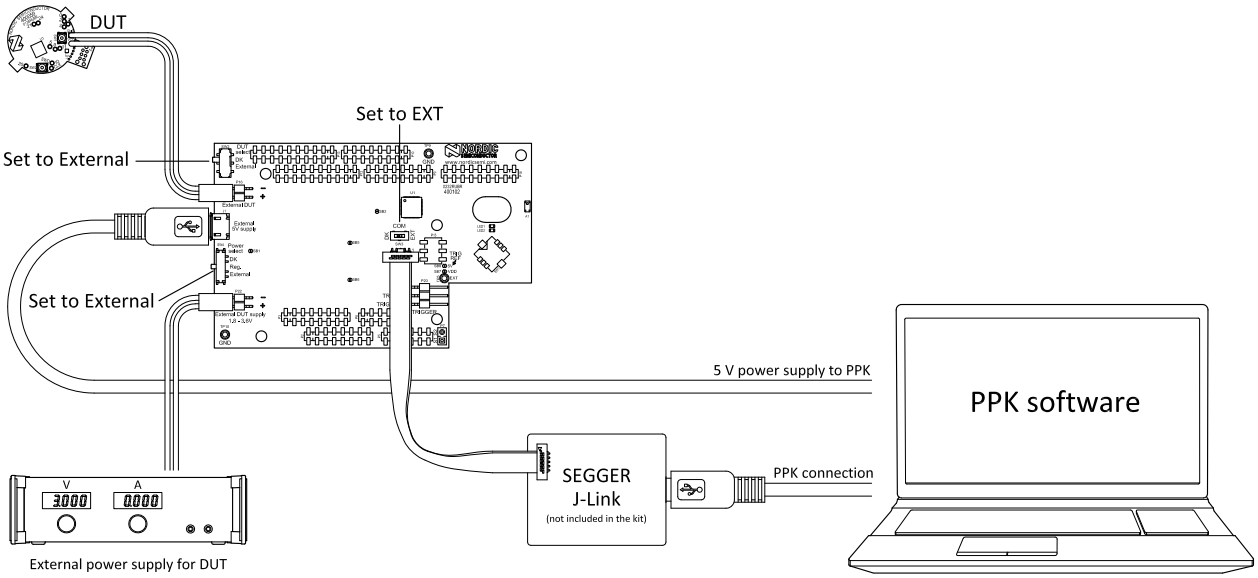


Figure 14: Current measurements standalone with an external power source

Make sure that the following are configured:

- The DUT select (**SW2**) switch is in the "External" position.
- The custom hardware (DUT) is connected to the External DUT (**P16**) connector of the PPK.
- The power source is one of the following:
  - The PPK on-board regulator: Make sure that a USB cable with power is inserted into the External 5V supply (**J1**) USB connector of the PPK. Set the Power select (**SW4**) switch in the "Reg" position.
  - External power supply: In addition to the USB cable inserted in the External 5V supply (**J1**) USB connector, make sure that the external power is connected to the External DUT supply (**P22**) connector of the PPK (voltage range from 1.8 to 3.6 V). Set the Power select (**SW4**) switch in the "External" position.
- The additional SEGGER J-Link is connected to the Debug in (**P21**) connector on the PPK using the 10-pin flat cable. The USB cable is inserted into the SEGGER J-Link and connected to a computer running the PPK desktop application.
- The COM (**SW3**) switch is in the "EXT" position.

Chapter 6
Connecting the Power Profiler Kit to a computer

You need to connect the Power Profiler Kit (PPK) to a computer with a USB cable in order to use it.

1. Use a USB cable to connect the PPK to your computer.

   If the PPK is connected to an nRF5x DK, connect the USB cable to the nRF5x DK. If the PPK is running standalone, connect the USB cable to the PPK.
2. If you are using an external SEGGER J-Link in your configuration, use a USB cable to connect it to your computer.
3. If you are using the nRF5x DK, flip the nRF5x power switch to "ON".

   If Windows driver installation starts for the inserted DK, wait until it finishes before continuing.
4. Verify that the **LED1** is lit on the PPK.
5. Confirm that the connected configuration appears as a removable drive on your computer.

Your PPK is now connected to the computer. You are ready to start the PPK desktop application.

Chapter 7
Using the Power Profiler Kit desktop application

The Power Profiler Kit (PPK) must be configured correctly, connected to your computer, and powered before the desktop application can be started.

To start the PPK desktop application, do the following:

1. Navigate to the directory where you have installed your PPK software package.
2. Double-click the file `ppk.py`. If prompted for details, choose to run the file with Python.

   The PPK desktop application can also be started from the command line console. Make sure to navigate to the correct directory and run the following command:

   ```
   python.exe ppk.py
   ```

The PPK desktop application opens up. Two separate windows are displayed:

- The **Settings** window to the left with configuration and measurement controls, options, and settings
- The **Plots** window to the right with current measurement plots displaying average and trigger values

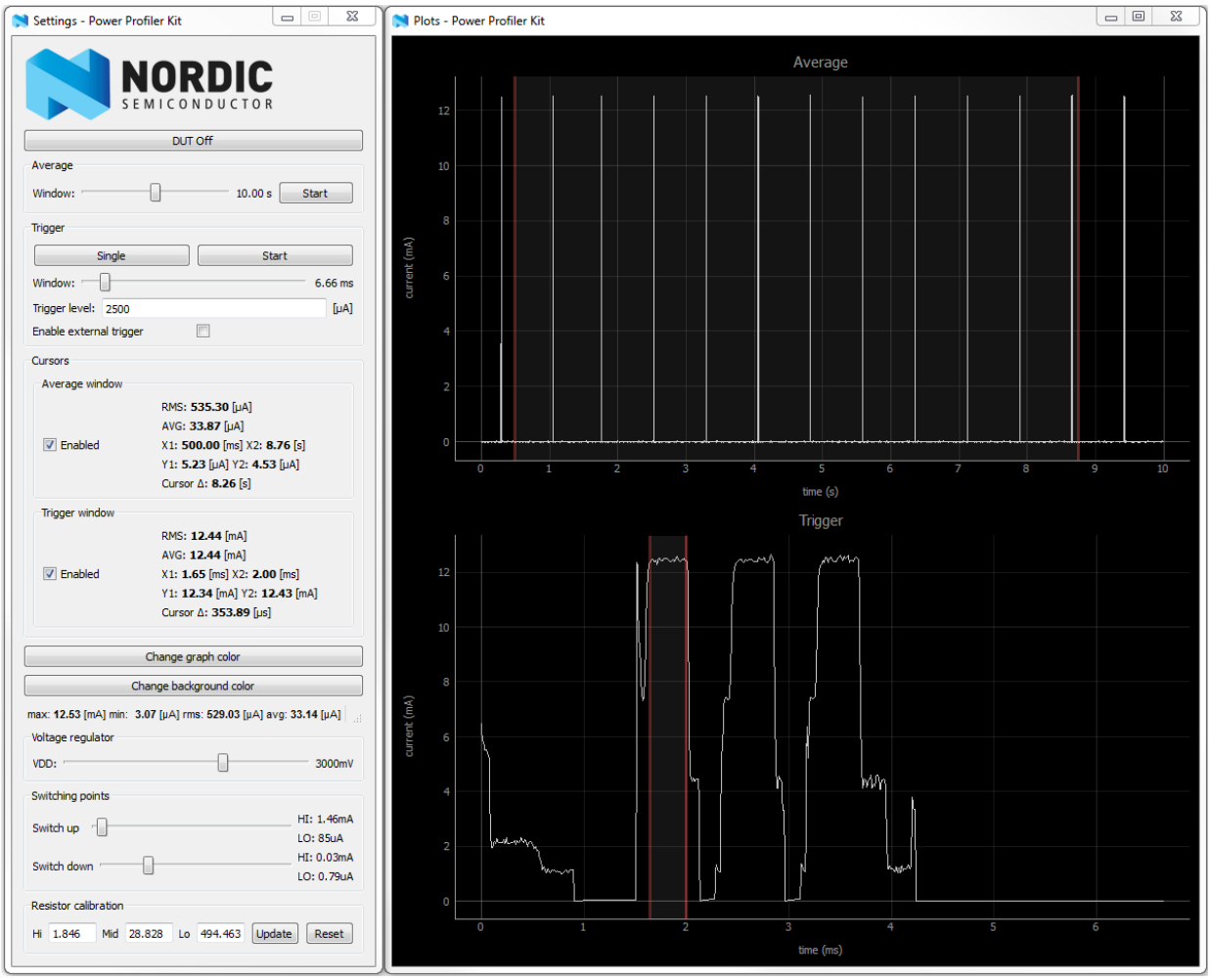


Figure 15: Settings and Plots windows of the PPK desktop application

7.1 Configuration settings

A continuously updated calculation of average, RMS, maximum, and minimum current consumption is made during the measurement and displayed in the **Settings** window of the PPK desktop application.

The available configuration settings in the **Settings** window of the PPK desktop application are:

DUT On/Off	Allows you to turn the power on and off for the DUT.
Average (Start/Stop and Window)	The **Average** section in the **Plots** window gives a graphical presentation of averaged samples. Each point in the plot is an average of 10 samples (measurements). The noise is filtered out and an accurate average measurement is given. Use the **Start**/**Stop** button to start or stop the average measurement. Using the **Window** option, the time span can be adjusted for the **Average** plot in the **Plots** window. It can be adjusted to up to 20 seconds.
Trigger (Single, Start/Stop, Window, Trigger level, Enable external trigger)	The **Trigger** section of the **Plots** window displays a number of raw samples with high resolution. The plot gives the current profile in x ms after a current of y µA is detected. To make a one-time capture of the triggered data, press the **Single** button. Use the **Pause**/**Start** button to pause or start the triggered data respectively. While running, the displayed data will be updated every time the current exceeds the trigger level. Using the **Window** option, the time span can be adjusted for the **Trigger** plot in the **Plots** window. Using the **Trigger level** option, the current is set for the **Trigger** plot in the **Plots** window. Select the option **Enable external trigger** to trigger the current measurement from an external source. Your external source needs then to be connected to the TRIG IN pin of the PPK TRIGGER (**P20**) connector.
Cursors (Average/Trigger window)	Both plots in the **Plots** window have cursors that can be adjusted within the whole time frame for selecting the areas of interest in the measured data set. Select/deselect the **Enabled** option to enable or disable the cursors. The X (X1 and X2) and Y (Y1 and Y2) values for the cursors and the cursor delta (Δ) are updated automatically as you move the cursors in the **Plots** window. The cursors have their own calculations (RMS and AVG), so you can measure only the interesting data (in the defined area of interest). The cursors

automatically update their calculations also when a plot is stopped. This makes it easy to select the average data consumption at specific events.

Change graph color

Used to adjust the color of the graph (plot) displayed in the **Plots** window of the PPK desktop application.

Change background color

Used to adjust the background color of the **Plots** window.

Voltage regulator (supply voltage - VDD)

Used to adjust the supply voltage. Adjusting the voltage will only have an effect if the power is supplied by the on-board regulator (the Power select (**SW4**) switch is in the "Reg" position).

Switching points

The PPK has three different measurement ranges (low/medium/high). The switching between them is done automatically based on the defined switching points. If your DUT has a current consumption that is close to a switching point between the different ranges, erroneous or misleading power measurements can be made. To avoid this, you can adjust the values for the switching points.

Use the **Switch up** setting (move the slider left/right) to define the switching point from low to medium range (**LO** value) and the switching point from medium to high range (**HI** value). Changing the switching points in the **Switch up** setting will automatically adjust the switching points in the **Switch down** setting.

Use the **Switch down** setting (move the slider left/right) to define the switching point from high to medium range (**HI** value) and the switching point from medium to low range (**LO** value).

For more information about the switching points, see The measurement system on page 8.

Resistor calibration

Each PPK is factory calibrated and the resistor values are displayed in the **Resistor calibration** section of the **Settings** window. If recalibration of your PPK is needed, the resistor values can be adjusted.

Before adjusting these values, connect an accurate current load to the External DUT (**P16**) connector. While measuring the current with the PPK, adjust the resistor values so that the measured current matches the current load. Press the **Update** button to update the PPK with new resistor values.

You can always go back to default factory values by pressing the **Reset** button.

Typical current ranges:

- Lo: 1 µA - 70 µA
- Mid: 340 µA - 1.2 mA

- Hi: 5.6 mA - 70 mA

7.2 Options for the Plots window

The **Plots** window consists of two parts: the **Average** plot for longer acquisition times and the **Trigger** plot for high-accuracy plots of triggered events. In addition to the settings for the plots in the **Settings** window of the PPK, there are several options for the plots in the **Plots** window.

> **Caution:** Depending on computer configuration, both plots cannot run in parallel. Data transfer may slow down. For better results, it is recommended to use only one plot at a time. To do so, click **Stop** for the plot you decide not to use.

In the **Plots** window, you can:

- Zoom in/out
- Scale the plots, both X and Y axis
- Move the cursors
- Transform the plot to logarithmic view or power spectrum (FFT)
- Export the plots to standard image files (for example PNG, TIF, JPG), scalable vector graphics (SVG) and CSV

The options are as follows:

Zooming in/out

To zoom in or out of a plot, place your mouse over the plot and use the mouse scroll wheel. Scroll up to zoom in. Scroll down to zoom out.

Scaling the plots (X/Y axis)

Scale the plots by using the mouse operations or the context menu.

- Using a mouse: Click and hold the right mouse-button as you move the mouse across the plot: left/right for the X axis or up/down for the Y axis.
- Using the context menu: Right-click the mouse over a plot. In the context menu, select the **X Axis**/**Y Axis** option and then the appropriate action for the X/Y axis. Select the **View All** option to view the entire plot.

Moving the cursors

To move a cursor, click and hold the left mouse-button over the selected cursor and drag to where you want to place it.

Transforming the plots

To transform a plot to logarithmic view or power spectrum (FFT), use the context menu. Select **Plot Options** > **Transforms**. Then select one of the three options: **Power Spectrum (FFT)**, **Log X**, or **Log Y**. Deselect the option to go back to the default view.

Exporting the plots

Select **Export...** in the context menu. The **Export** dialog box will appear.

To export both plots, select the **Entire scene** option.

To export each plot individually, select either the first **Plot** item for the **Average** plot or the second for the **Trigger** plot.

You can also select the export format (image file, scalable vector graphics, or CSV from plot data).

The **Matplotlib Window** option is not in use in the current version of the PPK.

Depending on the selected export format, you may be able to define some export options.

Click **Export** to export to a selected format.

Click **Copy** to place the selection on the clipboard.

Click **Close** to close the **Export** dialog box.

Chapter 8
Upgrading the firmware

The Power Profiler Kit (PPK) firmware on the nRF52832 SoC can be upgraded in either one of two ways.

Option 1

The nRF5x DK will enumerate as a mass storage device. To update the firmware of the PPK, make sure the COM switch is set in the DK position, and drag and drop the HEX file to the "JLINK" drive.

Option 2

Upgrade using nRFgo Studio tool from Nordic.

The necessary firmware is included in the PPK software package with the following naming convention: `PPK_XXX.HEX`, where the XXX is the version number.

In the following procedure, the nRF52 DK is used as a reference, but the nRF51 DK can also be used.

To be able to program the PPK, complete the following steps:

1. The PPK needs to be connected to a SEGGER J-Link device. The nRF5x DK has the SEGGER J-Link built in and can be used by connecting to a USB cable. Connect the PPK to the nRF5x DK. Make sure that the COM switch is in the "DK" position. See Figure 9: Current measurements on the nRF5x DK on page 15.
2. The nRFgo Studio is used to erase memory content or program the application HEX file onto the nRF52832 SoC on the PPK. Open the nRFgo Studio on your computer. In the **Device Manager** pane, select the **nRF52 development boards**.
3. Select the correct SEGGER entry with the ID matching the nRF52 DK connected to the PPK.
4. Click the **Erase all** button to clear everything in the flash memory.
5. Select the **Program Application** tab. Click **Browse...** to navigate to and select the HEX file to program.
6. Deselect the option **Lock entire chip from readback**.
7. Click **Program**, which will program the HEX file onto the selected chip.

Chapter 9
Electrical specifications

These specifications contain the property values that are essential for using the Power Profiler Kit (PPK).

Table 5: Environmental specifications

Item	Name	Min	Typ	Max	Unit	Description
Operating temperature	Op_Temp	15		30	°C	

Table 6: Power supply specifications

Item	Name	Min	Typ	Max	Unit	Description
DUT voltage	VDD_DUT	1.8		3.6	V	
External supply voltage	VDD_EXT	1.8		3.6	V	
Micro-USB supply voltage	V5V	4.5		5.5	V	USB voltage tolerances

Table 7: Measurement specifications

Item	Name	Min	Typ	Max	Unit	Description
Maximum DUT admissible current	Max_I			70	mA	
Measurement resolution						
1-70 µA range	R1_Resol		0.2		µA	
70 µA – 1 mA range	R2_Resol		3		µA	
1 – 70 mA range	R3_Resol		50		µA	
Measurement accuracy						
1-70 µA range	R1_Accuracy		+/- 20		%	Readout on Average value
1-70 uA range	R1_Offset		+-2		R1_Resol	
70 µA – 1 mA range	R2_Accuracy		+/- 15		%	Readout on Average value
70 uA-1 mA range	R2_Offset		+-2		R2_Resol	
1 – 70 mA range	R3_Accuracy		+/- 15		%	Readout on Average value
1-70 mA range	R3_Offset		+-2		R3_Resol	

Item	Name	Min	Typ	Max	Unit	Description
Sampling rate	Meas_Frequency		77		kHz	Fixed value

Chapter 10
Troubleshooting

Here are some basic troubleshooting steps to help you fix issues you may encounter when using the Power Profiler Kit (PPK).

My PPK desktop application won't start	Make sure the PPK board is powered and connected to the computer. Try running the desktop application from the command line as described in Using the Power Profiler Kit desktop application on page 21. Inspect the error output. You are most likely missing a SEGGER connection, or the PPK has been flashed with the wrong firmware. If upgrading has failed for some reason, run the "recover_ppk.py" script in the software folder. This should recover the board to the latest firmware.
I am only measuring noise	Make sure you have prepared the nRF5x DK for power measurements by cutting the **SB9** as described in Step 1 in Quick start. Alternatively, check that the DUT select (**SW2**) switch is in the correct position for your configuration.
My measurements fluctuate when I should have a steady current draw	Your DUT may have a current consumption that is close to a switching point causing rapid switching up and down between the ranges and creating measurement errors/distorted plots. Try adjusting the switching points.

For personalized support from our technical support team, sign up for My Page.

For more information, visit Nordic Developer Zone.

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