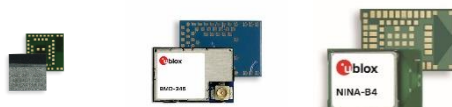# RC oscillator configuration for nRF5 open CPU modules

Bluetooth Low Energy

Application note

Abstract

The ANNA-B40, BMD-3, NINA-B40, and NORA-B1 open CPU modules may be used without an external low-frequency crystal. This application note describes the necessary steps to modify application projects in nRF5 SDK and nRF Connect SDK (Zephyr) to select the internal RC oscillator as the low-frequency clock source.

Document information

Title	RC oscillator configuration for nRF5 open CPU modules	
Subtitle	Bluetooth Low Energy	
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This document applies to the following products:

Product name
ANNA-B112 (open CPU only). See the ANNA B1 SIM for u-connectXpress® [1].
ANNA-B40
BMD-3
NINA-B306-01B
NINA-B40
NORA-B1

Contents

1   Introduction

The low-frequency clock for applications integrating the modules listed in the Document information can be sourced from an internal RC oscillator or an external crystal.

For the lowest possible power consumption, choose an external crystal with loading capacitors connected to GPIO pins **P0.00** and **P0.01**. An external crystal also provides the tighter tolerances necessary for some protocols like ANT+ [3].

☞ It is not possible to use an external low frequency crystal oscillator (LFXO) with NINA-B306-01B modules. This means that the application software based on these modules must be configured for use with an internal RC oscillator clock source.

In extremely cost-sensitive applications or in applications where the physical space required to accommodate the crystal and capacitors is not available, it might be necessary to utilize all GPIO pins. In these instances, it is likely that use of an internal RC oscillator represents the best design option. The LFCLK specifications of each nRF CPU are described in references **Fel! Hittar inte referenskälla.**, **Fel! Hittar inte referenskälla.**, **Fel! Hittar inte referenskälla.**, [7], and [8]. Either of the low-frequency clock sources can be used Bluetooth® Low Energy applications. See also the Bluetooth SIG website [2].

2   nRF5 SDK configuration

☞   NORA-B1 is not supported by nRF5 SDK. See also nRF Connect SDK (NCS).

2.1   External low-frequency crystal oscillator (LFXO)

An LFXO is used In all examples included in the nRF5 SDK. As the external crystal and capacitors featured in these examples are included in the EVKs, no file modifications are necessary.

2.2   Internal RC low-frequency oscillator (LFRC)

Each nRF5 SDK example project is provided with a header file called `sdk_config.h`. Three sections of this file must be modified to configure the LFRC. As the `sdk_config.h` file is rather large and differs in each SDK release, specific line numbers are not given. Use a text search to identify the sections that must be modified.

☞   Recompile the application to apply the file changes described in the following subsections.

2.2.1   SoftDevice clock configuration

The first section to modify contains four parameters to select the internal RC oscillator and configure SoftDevice timing. Locate the following section in the application's `sdk_config.h` file:

```
// </h>
//=========================================================
// <h> Clock - SoftDevice clock configuration
//=========================================================
```

See the lines in **bold** below**.** The new values are assigned for clock selection and timing and the original value for the LFXO is noted as a comment.

2.2.1.1   SoftDevice clock source

```
// <o> NRF_SDH_CLOCK_LF_SRC - SoftDevice clock source.
// <0=> NRF_CLOCK_LF_SRC_RC
// <1=> NRF_CLOCK_LF_SRC_XTAL
// <2=> NRF_CLOCK_LF_SRC_SYNTH
#ifndef NRF_SDH_CLOCK_LF_SRC
#define NRF_SDH_CLOCK_LF_SRC 0 // was 1
#endif
```

2.2.1.2   SoftDevice calibration timer interval

```
SoftDevice calibration timer interval
// <o> NRF_SDH_CLOCK_LF_RC_CTIV - SoftDevice calibration timer interval.
#ifndef NRF_SDH_CLOCK_LF_RC_CTIV
#define NRF_SDH_CLOCK_LF_RC_CTIV 16 // was 0 (ignored)
#endif
```

2.2.1.3   SoftDevice calibration timer interval under constant temperature

```
// <o> NRF_SDH_CLOCK_LF_RC_TEMP_CTIV - SoftDevice calibration timer interval under
//                                      constant temperature.
// <i> How often (in number of calibration intervals) the RC oscillator shall be
// calibrated if the temperature has not changed.

#ifndef NRF_SDH_CLOCK_LF_RC_TEMP_CTIV
#define NRF_SDH_CLOCK_LF_RC_TEMP_CTIV 2 // was 0 (ignored)
#endif

// <o> NRF_SDH_CLOCK_LF_ACCURACY - External clock accuracy used in the LL to
//                                  compute timing.
```

```
// <0=> NRF_CLOCK_LF_ACCURACY_250_PPM
// <1=> NRF_CLOCK_LF_ACCURACY_500_PPM
// <2=> NRF_CLOCK_LF_ACCURACY_150_PPM
// <3=> NRF_CLOCK_LF_ACCURACY_100_PPM
// <4=> NRF_CLOCK_LF_ACCURACY_75_PPM
// <5=> NRF_CLOCK_LF_ACCURACY_50_PPM
// <6=> NRF_CLOCK_LF_ACCURACY_30_PPM
// <7=> NRF_CLOCK_LF_ACCURACY_20_PPM
// <8=> NRF_CLOCK_LF_ACCURACY_10_PPM
// <9=> NRF_CLOCK_LF_ACCURACY_5_PPM
// <10=> NRF_CLOCK_LF_ACCURACY_2_PPM
// <11=> NRF_CLOCK_LF_ACCURACY_1_PPM
#ifndef NRF_SDH_CLOCK_LF_ACCURACY
#define NRF_SDH_CLOCK_LF_ACCURACY 1 // was 7 (for a 20ppm crystal)[1]
#endif
```

2.2.2 Clock peripheral driver

Newer examples utilize the "NRFX" clock drive for non-radio low-frequency timing (timers, RTC, etc.). Locate the `nrfx_clock` section:

See the line in **bold** below. The new value to select the RC oscillator is assigned and the original value for the LFXO is noted as a comment.

```
// <e> NRFX_CLOCK_ENABLED - nrfx_clock - CLOCK peripheral driver
//=========================================================
#ifndef NRFX_CLOCK_ENABLED
#define NRFX_CLOCK_ENABLED 1
#endif

// <o> NRFX_CLOCK_CONFIG_LF_SRC - LF Clock Source
// <0=> RC
// <1=> XTAL
// <2=> Synth
// <131073=> External Low Swing
// <196609=> External Full Swing
#ifndef NRFX_CLOCK_CONFIG_LF_SRC
#define NRFX_CLOCK_CONFIG_LF_SRC 0 // was 1
#endif
```

2.2.3 Legacy clock peripheral driver

The legacy clock peripheral driver is also included to provide backward compatibility with older code ported to a newer SDK version: Locate the `nrf_drv_clock` section:

See the line in **bold** below. The new value to select the RC oscillator is assigned and the original value for the LFXO is noted as a comment.

```
// <e> NRF_CLOCK_ENABLED - nrf_drv_clock - CLOCK peripheral driver - legacy layer
//=========================================================
#ifndef NRF_CLOCK_ENABLED
#define NRF_CLOCK_ENABLED 1
#endif
// <o> CLOCK_CONFIG_LF_SRC - LF Clock Source
// <0=> RC
// <1=> XTAL
// <2=> Synth
// <131073=> External Low Swing
// <196609=> External Full Swing
#ifndef CLOCK_CONFIG_LF_SRC
#define CLOCK_CONFIG_LF_SRC 0 // was 1
#endif
```

---

[1] Although the nRF52832 product specification calls out ±250 ppm for LFRC accuracy, SDK v16.0.0 and newer suggests using ±500 ppm. Other nRF52 CPUs specify ±500 ppm for LFRC.

2.3   Synthesized low-frequency clock (LFSYNT)

nRF5 CPUs also provide a synthesized low-frequency clock option. While the processor provides the tightest tolerance (<10 ppm), it also uses the most power since the HFCLK must always be enabled. Nordic Semiconductor does not recommend these processors for use with current SoftDevices[2].

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[2] See the Nordic Semiconductor SoftDevice release notes contained within the downloaded zip file

3   nRF Connect SDK (NCS) configuration

To use a different clock source, the necessary changes may be made in one of two places: In the BSP `<board>_<cpu>_defconfig` file or in the application overlay project file `prj.conf`.

Use `<board>_<cpu>_defconfig` when creating a new BSP for custom hardware. For example, the BSP for the EVK-NINA-B4 can be found in the NCS directory tree at:

`.\ncs\vX.Y.Z\zephyr\boards\arm\ubx_evkninab4_nrf52833`

To make a custom BSP, make a copy of the folder for the EVK that matches the u-blox module in use, and then rename both the folder and corresponding files to match the custom hardware, as in the following NORA-B40 example:

`productname_nrf52833`

Files within the folder beginning with `ubx_` would also need to be renamed to match the new hardware name, including `productname_nrf52833_defconfig`.

☞   Including the CPU part number is not required. Most BSP packages list it though.

Use `prj.conf` when evaluating a sample application without modifying an existing EVK BSP. `prj.conf` is an overlay file that overrides BSP settings for a particular application.

⚠   Edits to `prj.conf` or `<board>_<cpu>_defconfig` must be made prior to using "Open nRF Connect SDK Project" in SEGGER Embedded Studio.

The information presented below would be added or changed in either location, but not both. All configuration options may be found at [12].

3.1   External low-frequency crystal oscillator (LFXO)

The LFXO is the default for the u-blox EVK board support packages (BSP). The external crystal and capacitors are provided on the EVKs, so no modifications to the BSP files are necessary. When creating a BSP for custom hardware, the EVK corresponding to the module in use may be used as a starting point.

3.2   Internal RC low-frequency oscillator (LFRC)

To use LFRC, add the following lines to either the BSP `<boardname>_<cpu>_defconfig` file, or the application's `prj.conf` file.

```
CONFIG_CLOCK_CONTROL_NRF_K32SRC_RC=y
CONFIG_CLOCK_CONTROL_NRF_K32SRC_500PPM=y
```

☞   For multiple-core modules, such as the NORA-B1 containing the nRF5340, this information needs included in the files for each core.

3.3   Internal synthesized low-frequency clock (LFSYNT)

To use LFSYNT, add the following line to either the BSP `<boardname>_<cpu>_defconfig` file, or the application's `prj.conf` file.

```
CONFIG_CLOCK_CONTROL_NRF_K32SRC_SYNTH=y
```

☞   For multiple-core modules, such as the NORA-B1 containing the nRF5340, this information must be included in the files for each core.

Appendix

A Glossary

Abbreviation	Definition
ANT+	Low power wireless communication standard
ARM	Arm (Advanced RISC Machines) Holdings
BSP	Board Support Package
CPU	Central Processing Unit
LFXO	Low-frequency crystal oscillator
LFRC	Low-frequency RC oscillator
LFSYNT	Synthesized low-frequency oscillator
NCS	nRF Connect SDK
PPM	Parts per million
SDK	Software Development Kit
SES	SEGGER Embedded Studio
SoftDevice	Nordic Semiconductor implementation of the Bluetooth communications stack

Table 1: Explanation of the abbreviations and terms used

Related documents

[1] ANNA-B1 system integration manual, UBX-18009821
[2] Bluetooth SIG website
[3] ANT+ standard
[4] Nordic Semiconductor nRF52810 LFCLK controller
[5] Nordic Semiconductor nRF52811 LFCLK controller
[6] Nordic Semiconductor nRF52832 LFCLK controller
[7] Nordic Semiconductor nRF52833 LFCLK controller
[8] Nordic Semiconductor nRF52840 LFCLK controller
[9] Nordic Semiconductor S140 SoftDevice[3]
[10] Nordic Semiconductor nRF5 SDK
[11] Nordic Semiconductor nRF Connect SDK
[12] NCS / Zephyr configuration options

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[3] Other SoftDevice versions (S112, S113, S132) are subsets of S140

Revision history

Revision	Date	Name	Comments
R01	18-Feb-2020	brec	Initial release
R02	15-Jan-2021	mape	Included minor typographical corrections and extended document scope to include NINA-B306-01B
R03	03-Sep-2021	brec	Added nRF Connect SDK information, extended document scope to include ANNA-B40 and NORA-B1

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