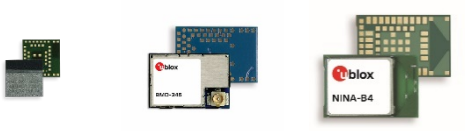
RC oscillator configuration for nRF5 open CPU modules

Bluetooth Low Energy

Application note



Abstract

The BMD-3 and NINA-B40 open CPU modules may be used without an external low frequency crystal. This application note describes the necessary steps to modify an application project to select the internal RC oscillator as the low frequency clock source.

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Document information

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This document applies to the following products:

Product name
ANNA-B112 (open CPU only, see ANNA B1 SIM for u-connect® [1])
BMD-3
NINA-B40

Contents

1 Introduction

For applications running on the ANNA-B1, BMD-3 and NINA-B40 series modules, there is a choice of the low-frequency oscillator source. The lowest possible power consumption scenario uses an external crystal and loading capacitors connected to GPIO pins named P0.00 and P0.01. Using the crystal also provides a tighter tolerance which is required for certain protocols, for example ANT+ [3].

Certain applications may need to utilize all of the GPIO pins, may be size-constrained where the space required for the crystal and capacitors is not available, or extremely cost conscious. For these applications, internal RC oscillator may be selected. Links to the LFCLK product specification sections of the nRF CPUs are in [4], [5], [6], and [7].

Bluetooth® Low Energy applications may use either low frequency clock source [2].

2 SDK configuration

After making the necessary modifications, recompile the application to apply the changes.

2.1 External low frequency crystal oscillator (LFXO)

For all of the examples provided by Nordic Semiconductor in the nRF5 SDK, the default is the LFXO. The external crystal and capacitors are provided on the EVKs, so no 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`. Within this file, three sections need minor modification in order to select the LFRC. The `sdk_config.h` file is rather large, and changes with each SDK release, so specific line numbers are not mentioned. A text search will show the necessary sections.

2.2.1 SoftDevice clock configuration

The first section to modify contains four parameters to configure SoftDevice timing. Locate the following section in sdk_config.h:

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

For each parameter 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:

```
// <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:

```
// <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
```

2.3 Synthesized low frequency clock (LFSYNT)

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

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

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

Appendix

A Glossary

Abbreviation	Definition
ANT+	Low power wireless communication standard
ARM	Arm (Advanced RISC Machines) Holdings
CPU	Central Processing Unit
LFXO	Low frequency crystal oscillator
LFRC	Low frequency RC oscillator
LFSYNT	Synthesized low frequency oscillator
PPM	Parts per million
SDK	Software Development Kit
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
[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 nRF52840 LFCLK controller
[8] Nordic Semiconductor S140 SoftDevice[3]

For regular updates to u-blox documentation and to receive product change notifications, register on our homepage (www.u-blox.com).

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

Revision history

Revision	Date	Name	Comments
R01	18-Feb-2020	brec	Initial release

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