



nRF51822 specification for Extended Industrial Temperature range

Multiprotocol *Bluetooth*® 4.1 low energy/2.4 GHz RF SoC

Specification v1.0

Addendum to nRF51822 Product Specification v3.1

This addendum describes the deviations that apply when operating the nRF51822 chip in the -40 to +105°C temperature range.

For information on the specifications when operating the nRF51822 chip in the Consumer Temperature Range (-25 to +75°C), see the *nRF51822 Product Specification v3.1*.

This document applies to the following chip variants:

nRF51822 variant	Build code
QFAA	Hx0 ¹
CEAA	Ex0 ¹

1. The x in the build code can be any digit between 0..9.

Table 1 nRF51822 variants qualified for the -40 to +105°C temperature range

1 Introduction

The nRF51822 chip variants mentioned in *Table 1* on page 1 have been qualified for operating in the -40 to +105°C temperature range.

This document specifies the performance when operating in the -40 to +105°C temperature range. The values in this document replace the corresponding values in the *nRF51822 Product Specification v3.1* when operating outside the Consumer Temperature Range (-25 to +75°C) but inside the -40 to +105°C temperature range.

The main change for temperatures above +85°C is that the performance in the 1 Mbps non-BLE mode cannot be ensured. However, the performance in the 1 Mbps BLE mode is still within the specifications. Therefore all references to 1 Mbps non-BLE mode are removed from the specification.

The following paragraphs highlights the changes to be taken in considerations when using this part in this extended temperature range.

2 Deviations from the nRF51822 Product Specification v3.1

This chapter lists where there are differences from *nRF51822 Product Specification v3.1*, and the chapter or section name and number is referring to the chapter or section in the *nRF51822 Product Specification v3.1*. Changed values are written with bold font, and values or information that is not valid in the Extended Industrial Temperature Range are written with strikethrough font.

Key features on the front page:

- 2.4 GHz transceiver
 - 250 kbps, ~~1 Mbps~~, 2 Mbps, **1 Mbps BLE** supported data rates
- On-air compatibility with nRF24L series **for 250 Kbps and 2 Mbps**
- Flexible power management
 - Supply voltage range **1.9 V** to 3.6 V

3.4.1 Power supply

nRF51 supports three different power supply alternatives:

- Internal LDO setup
- DC/DC converter setup
- ~~Low voltage mode setup~~

3.4.1.3 Low voltage mode setup

~~Devices can be used in low voltage mode where a steady 1.8 V supply is available externally.~~

4.1 2.4 GHz radio (RADIO)

The nRF51 series 2.4 GHz RF transceiver is designed and optimized to operate in the worldwide ISM frequency band at 2.400 to 2.4835 GHz. Radio modulation modes and configurable packet structure enable interoperability with *Bluetooth*® low energy (BLE), ANT™, Enhanced ShockBurst™, and other 2.4 GHz protocol implementations.

The transceiver receives and transmits data directly to and from system memory for flexible and efficient packet data management. The nRF51 series transceiver has the following features:

- General modulation features
 - GFSK modulation
 - Data whitening
 - On-air data rates
 - 250 kbps
 - ~~1 Mbps~~
 - 2 Mbps
- Transmitter with programmable output power of +4 dBm to -20 dBm, in 4 dB steps
- Transmitter whisper mode -30 dBm
- RSSI function (1 dB resolution)
- Receiver with integrated channel filters achieving maximum sensitivity
 - -96 dBm at 250 kbps
 - -93 dBm at 1 Mbps BLE
 - ~~-90 dBm at 1 Mbps~~
 - -85 dBm at 2 Mbps

- RF Synthesizer
 - 1 MHz frequency programming resolution
 - 1 MHz non-overlapping channel spacing at 1 Mbps and 250 kbps
 - 2 MHz non-overlapping channel spacing at 2 Mbps
 - Works with low-cost ± 60 ppm 16 MHz crystal oscillators
- Baseband controller
 - EasyDMA RX and TX packet transfer directly to and from RAM
 - Dynamic payload length
 - On-the-fly packet assembly/disassembly and AES CCM payload encryption
 - 8 bit, 16 bit, and 24 bit CRC check (programmable polynomial and initial value)

7 Operating conditions

Changes in Table 20 (within the Consumer Temperature Range the specifications remains unchanged):

- New value for Min. voltage in the *Supply voltage, internal LDO setup* row.
- The row *Supply voltage, low voltage mode setup* is not valid.
- New values for Min. and Max. temperature in the *Operating temperature* row.

Symbol	Parameter	Notes	Min.	Typ.	Max.	Units
VDD	Supply voltage, internal LDO setup		1.9	3.0	3.6	V
VDD	Supply voltage, DC/DC converter setup		2.1	3.0	3.6	V
VDD	Supply voltage, low voltage mode setup	1	1.75	1.8	1.95	V
T _A	Operating temperature		-40	25	105	°C

1: DEC2 shall be connected to VDD in this mode.

Table 20 Operating conditions

8.2 Power management

Footnote no. 1 on Table 32 is not valid for -40 to +105°C temperature range.

8.5.1 General radio characteristics

Changes in Table 35 (within the Consumer Temperature Range the specifications remains unchanged):

- The row *Frequency deviation at 1 Mbps* is not valid.

Symbol	Description	Note	Min.	Typ.	Max.	Units	Test level
Δf_{1M}	Frequency deviation at 1 Mbps.			± 170		kHz	2

Table 35 General radio characteristics

8.5.2 Radio current consumption with DC/DC disabled

Changes in Table 36 (within the Consumer Temperature Range the specifications remains unchanged):

- The row *RX only run current at 1 Mbps* is not valid.
- The 1 Mbps data rate in the footnote is not valid for the rows with Note 1.

Symbol	Description	Note	Min.	Typ.	Max.	Units	Test level
$I_{TX,+4dBm}$	TX only run current at $P_{OUT} = +4$ dBm.	1		16		mA	4
$I_{TX,0dBm}$	TX only run current at $P_{OUT} = 0$ dBm.	1		10.5		mA	4
$I_{TX,-4dBm}$	TX only run current at $P_{OUT} = -4$ dBm.	1		8		mA	2
$I_{TX,-8dBm}$	TX only run current at $P_{OUT} = -8$ dBm.	1		7		mA	2
$I_{TX,-12dBm}$	TX only run current at $P_{OUT} = -12$ dBm.	1		6.5		mA	2
$I_{TX,-16dBm}$	TX only run current at $P_{OUT} = -16$ dBm.	1		6		mA	2
$I_{TX,-20dBm}$	TX only run current at $P_{OUT} = -20$ dBm.	1		5.5		mA	2
$I_{TX,-30dBm}$	TX only run current at $P_{OUT} = -30$ dBm.	1		5.5		mA	2
$I_{RX,1M}$	RX only run current at 1 Mbps.			13		mA	4
$I_{RX,1M BLE}$	RX only run current at 1 Mbps BLE.			13		mA	2

1. Valid for data rates 250 kbps, ~~1 Mbps~~, **1 Mbps BLE**, and 2 Mbps.

Table 36 Radio current consumption with DC/DC disabled (NOC, VDD = 3 V)

8.5.3 Radio current consumption with DC/DC enabled

Changes in Table 37 (within the Consumer Temperature Range the specifications remains unchanged):

- The row *RX only run current at 1 Mbps* is not valid.
- The 1 Mbps data rate in the footnote is not valid for the rows with Note 1.

Symbol	Description	Note	Min.	Typ.	Max.	Units	Test level
$I_{TX,+4dBm}$	TX only run current at $P_{OUT} = +4$ dBm.	1		11.8		mA	2
$I_{TX,0dBm}$	TX only run current at $P_{OUT} = 0$ dBm.	1		8.0		mA	2
$I_{TX,-4dBm}$	TX only run current at $P_{OUT} = -4$ dBm.	1		6.3		mA	2
$I_{TX,-8dBm}$	TX only run current at $P_{OUT} = -8$ dBm.	1		5.6		mA	2
$I_{TX,-12dBm}$	TX only run current at $P_{OUT} = -12$ dBm.	1		5.3		mA	2
$I_{TX,-16dBm}$	TX only run current at $P_{OUT} = -16$ dBm.	1		5.0		mA	2
$I_{TX,-20dBm}$	TX only run current at $P_{OUT} = -20$ dBm.	1		4.7		mA	2
$I_{TX,-30dBm}$	TX only run current at $P_{OUT} = -30$ dBm.	1		4.7		mA	2
$I_{RX,1M}$	<i>RX only run current at 1 Mbps.</i>			9.7		mA	2
$I_{RX,1M BLE}$	RX only run current at 1 Mbps.			9.7		mA	2

1. Valid for data rates 250 kbps, 1 Mbps, **1 Mbps BLE**, and 2 Mbps.

Table 37 Radio current consumption with DC/DC enabled (NOC, VDD = 3 V)

The **Figure 11** DC/DC conversion factor as function of VDD is not valid in the Extended Industrial temperature range. However, the DC/DC converter is still functioning, please see section 12.1.3 DC/DC converter setup in the nRF51 Series Reference Manual v3.0 for more information.

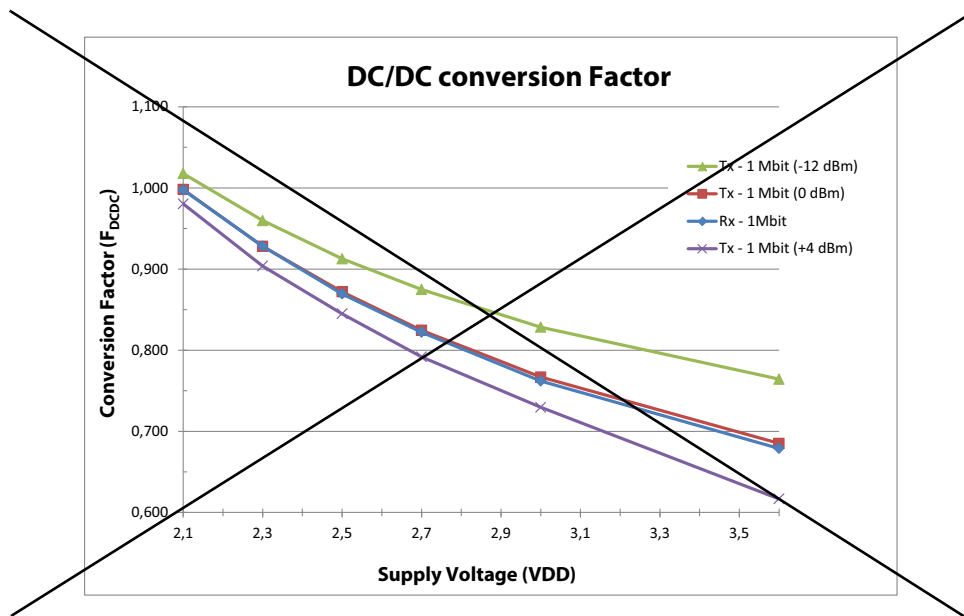


Figure 11 DC/DC conversion factor as function of VDD

8.5.4 Transmitter specifications

Changes in Table 38 (within the Consumer Temperature Range the specifications remains unchanged):

- The row *20 dB bandwidth for modulated carrier (1 Mbps)* is not valid.
- New value for Max. frequency in the *20 dB bandwidth for modulated carrier (250 kbps)* row.
- The row *1st Adjacent Channel Transmit Power. ±1 MHz (1 Mbps)* is not valid.
- The row *2nd Adjacent Channel Transmit Power. ±2 MHz (1 Mbps)* is not valid.

Symbol	Description	Min.	Typ.	Max.	Units	Test level
P_{BW1}	20 dB bandwidth for modulated carrier (1 Mbps).		950	1100	kHz	2
P_{BW250}	20 dB bandwidth for modulated carrier (250 kbps).		700	1300	kHz	2
$P_{RF1.1}$	1 st Adjacent Channel Transmit Power. ±1 MHz (1 Mbps).			-20	dBc	2
$P_{RF2.1}$	2 nd Adjacent Channel Transmit Power. ±2 MHz (1 Mbps).			-40	dBc	2

Table 38 Transmitter specifications

8.5.5 Receiver specifications

Changes in Table 39 (within the Consumer Temperature Range the specifications remains unchanged):

- The row *Sensitivity (0.1% BER) at 1 Mbps* is not valid.
- The rows for 1Mbps in the *RX selectivity - modulated interfering signal* section is not valid.

Symbol	Description	Min.	Typ.	Max.	Units	Test level
Receiver operation						
$PRX_{SENS,1M}$	Sensitivity (0.1% BER) at 1 Mbps.		-90		dBm	2
RX selectivity - modulated interfering signal						
1-Mbps						
CA_{CO}	C/I co-channel (1 Mbps).		12		dB	2
CA_{1ST}	1 st ACS, C/I 1 MHz.		4		dB	2
CA_{2ND}	2 nd ACS, C/I 2 MHz.		-24		dB	2
CA_{3RD}	3 rd ACS, C/I 3 MHz.		-30		dB	2
CA_{6th}	6 th ACS, C/I 6 MHz.		-40		dB	2
CA_{12th}	12 th ACS, C/I 12 MHz.		-50		dB	2
CA_{Nth}	N th ACS, C/I $f_c > 25$ MHz.		-53		dB	2

Table 39 Receiver specifications

8.12 Analog to Digital Converter (ADC) specifications

Changes in Table 51 (within the Consumer Temperature Range the specifications remains unchanged):

- New values for Min. and Max. in the *Gain error* row
- New values for Min. and Max. in the *Internal Band Gap reference voltage error* row
- References to 1.8 V are not valid for Industrial Temperature Range.

Symbol	Description	Note	Min.	Typ.	Max.	Units	Test level
e_G	Gain error.	1	-3		+3	%	2
$V_{REF_VBG_ERR}$	Internal Band Gap reference voltage error.		-2		+2	%	2
ADC_ERR_1V8				3		LSB	2
ADC_ERR_2V2	Absolute error when used for battery measurement at			2		LSB	2
ADC_ERR_2V6	1.8 V, 2.2 V, 2.6 V, 3.0 V, and	2		1		LSB	2
ADC_ERR_3V0	3.4 V.			1		LSB	2
ADC_ERR_3V4				1		LSB	2

1. Source impedance less than 5 k Ω .
2. Internal reference, input from VDD/3, 10 bit mode.

Table 51 Analog to Digital Converter (ADC) specifications

8.15 Temperature sensor (TEMP)

New values for Min. and Max. in the *Temperature sensor range* row in Table 54 (within the Consumer Temperature Range the specifications remains unchanged):

Symbol	Description	Note	Min.	Typ.	Max.	Units	Test level
T_{RANGE}	Temperature sensor range.		-40		105	$^{\circ}\text{C}$	N/A

Table 54 Temperature sensor

11.5.2 QFAA QFN48 schematic with low voltage mode setup

Not valid for -40 to +105°C temperature range.

11.8.2 CEAA WLCSP schematic with low voltage mode setup

Not valid for -40 to +105°C temperature range.

3 Typical characteristics

All plots are at VDD = 3 V, DC/DC converter disabled.

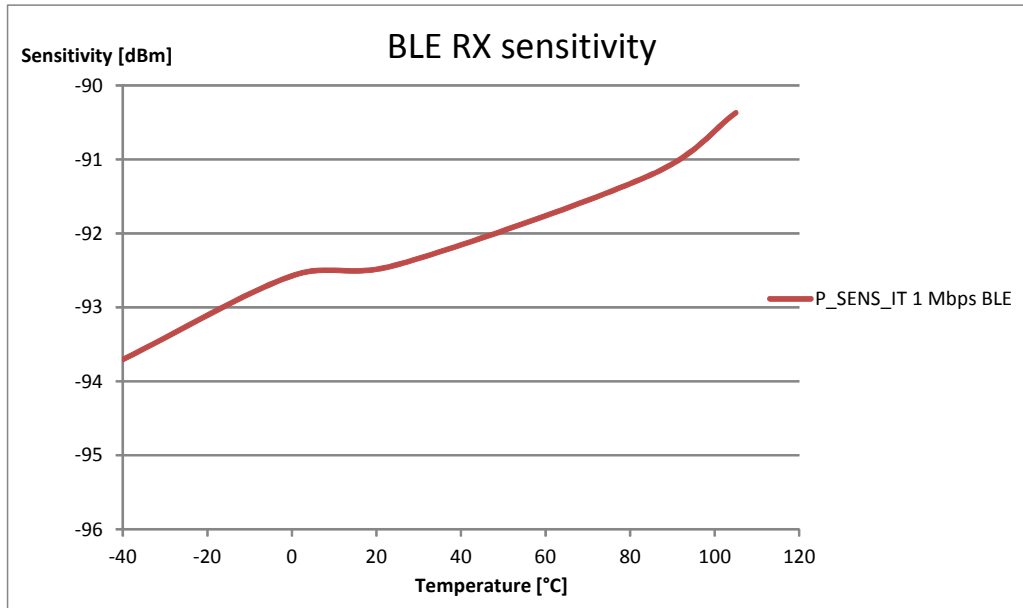


Figure 1 BLE RX sensitivity vs. temperature

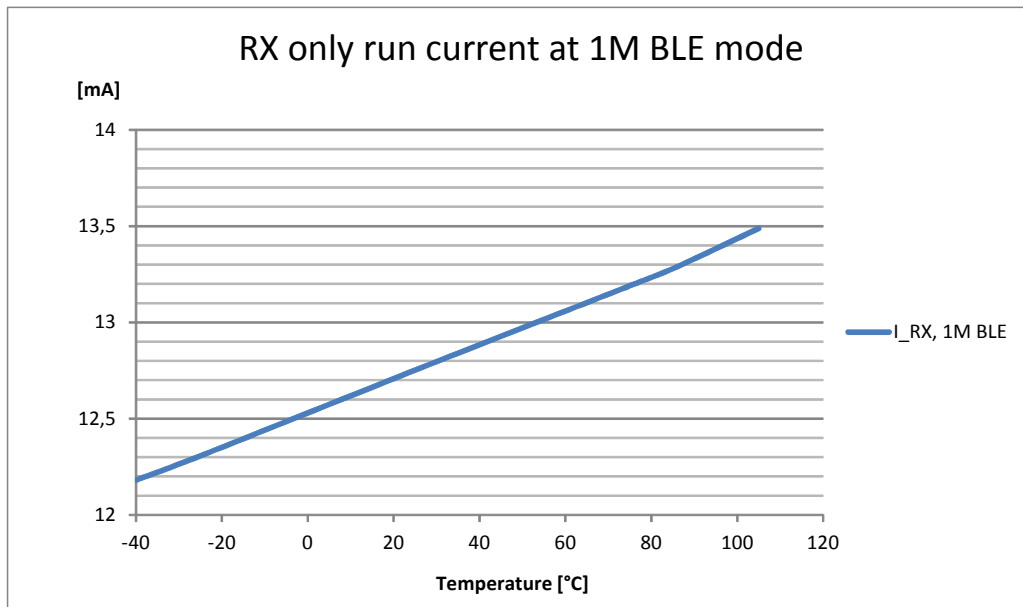


Figure 2 RX only run current at 1M BLE mode

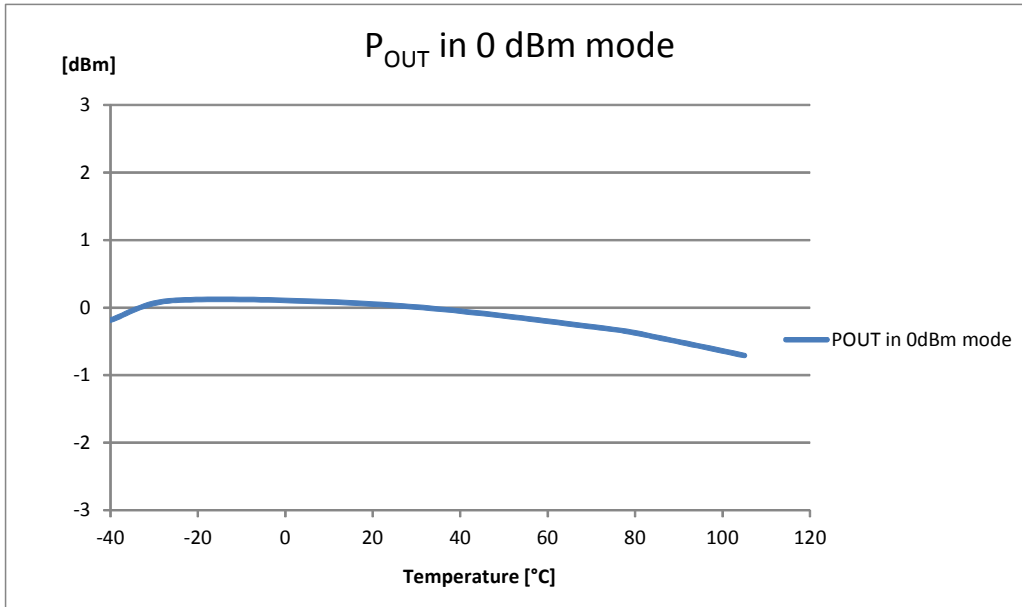


Figure 3 P_{OUT} in 0 dBm mode.

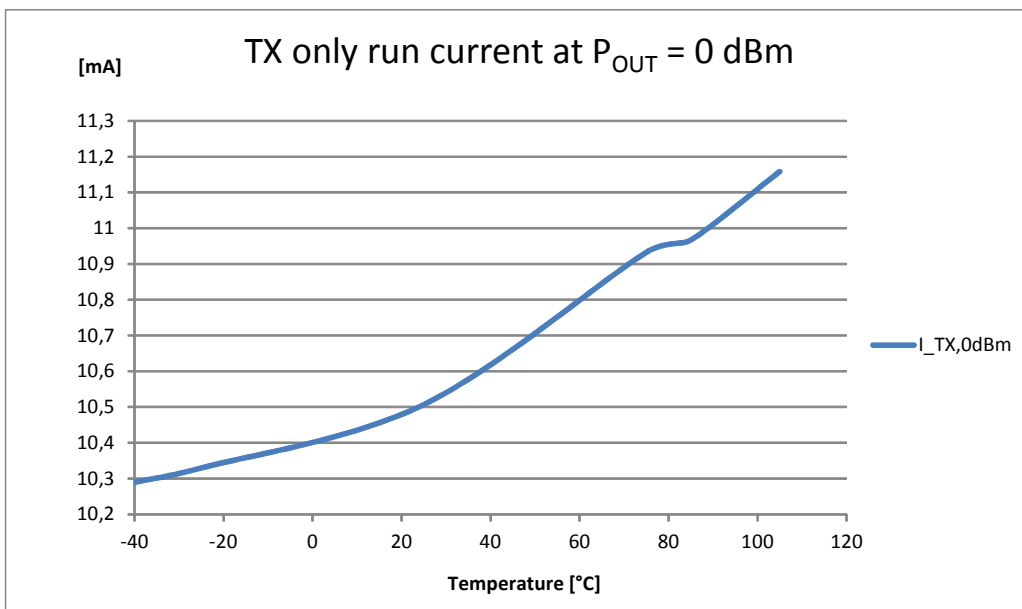


Figure 4 TX only run current at P_{OUT} = 0 dBm.

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Revision History

Date	Version	Description
June 2015	1.0	First release.