u-connectXpress

Bluetooth throughput

Application note

Abstract

This application note shows the Bluetooth throughput for u-blox stand-alone modules using u-connectXpress software.

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Document information

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This document applies to the following products:

Product name	Software version
ANNA-B112	2.0.x
	3.0.x
NINA-B11x	3.0.1
	4.0.0
	5.0.x
	6.0.x
NINA-B22x	1.0.x
	2.1.x
NINA-B31x	2.0.x
	3.0.x
NINA-W15x	2.1.x

Contents

1 Introduction

This application note provides Bluetooth low energy throughput measurement results for the different device-to-device combinations of u-blox stand-alone modules—used with u-connectXpress software. The software is used in different configurations of low energy Data packet Length Extension (DLE), Long Attribute Protocol MTU (ATT MTU) size and physical layer (PHY).

The measurement results have been obtained with the u-blox Low Energy Serial Port Service (SPS). This is the u-blox proprietary communication protocol for serial communication between Bluetooth Low Energy devices.

For more information regarding u-blox Serial Port Service (SPS) data transfer, see the u-blox Low Energy Serial Port Service Protocol Specification [2].

The measurement results given in this document have been obtained in a standard u-blox test environment. For optimal performance in each use case, customers are advised to test in their own chosen environments using the guidelines provided in this document. Chapter 2 provides some suggestions for the test setup.

Measurements have been performed with selected combinations of the devices listed below:

- NINA-B1 series
- NINA-B2 series
- NINA-B3 series
- NINA-W15 series
- ODIN-W2 series
- OBS421 series
- Android device
- iOS device

☞ The ANNA-B112 and NINA-B112 modules are not measured separately, as they are based on the same chipset and software base. The relationship between ANNA-B112 and NINA-B1 software versions is described in Table 1.

ANNA-B112 u-connectXpress software version	NINA-B1 u-connectXpress software version
ANNA-B112 SW 1.0	NINA-B1SW 4.0
ANNA-B112 SW 2.0	NINA-B1 SW 5.0

Table 1: Relationship between NINA-B1 and ANNA-B112 u-connectXpress software versions

☞ If you are using NINA-B1 Evaluation Kits (EVK) for measurements, note that the built-in Universal asynchronous receiver-transmitter (UART) to Universal Serial Bus (USB) on these EVKs introduces some performance loss in transmission to and from the module. For improved performance we recommend that you connect an FTDI cable to the UART pins on the EVK, as described in the EVK-NINA-B1 Evaluation kit for NINA-B1 modules user guide [5].

2 Test setup

The throughput measurements for u-blox stand-alone modules described in this document are derived from the components and configuration settings shown below. These settings also represent our recommended approach to customers when testing in their own chosen environments.

- Test and configuration using u-blox s-center evaluation software
- Two Bluetooth low energy devices (device A and device B) connected to each other using the configuration settings shown in each row of the throughput result tables.
- Baud rate set to the highest supported value (`AT+UMRS=1000000,1,8,1,1,1`).
- ATT MTU payload size settings configured using the AT command `AT+UBTLECFG=26,x` with x set as:
  - `x=1` module set to accept and negotiate a Maximum Transmission Unit (MTU) size of 247 bytes.
  - `x=2` module accepts an MTU size of 23 bytes only.
- Configure the minimum and maximum connection intervals for the module using AT commands:
  - `AT+UBTLECFG=4,x` (minimum value), and
  - `AT+UBTLECFG=5,x` (maximum value), where x is the connection interval in 1.25 ms units.
- Set both the Preferred Transmitter PHY and Preferred Receiver PHY and request a new PHY configuration for the Bluetooth low energy solutionto 2 Mbps using the following AT commands:
  - `AT+UBTLECFG=27,2, AT+UBTLECFG=28,2` (preferred physical layer), and
  - `AT+UBTLEPHYR=[conn_handle],2,2,` (request physical layer), where conn_handle is the connection handle that identifies the connection.
- Test modules in these communication modes:
  - Simplex: Send continuous data from device A to device B during 60 seconds and calculate the mean throughput during this period.
  - Duplex: Send continuous data from device A to device B and from device B to device A during 60 seconds and calculate the mean throughput of the data from device A to device B during this period.

For more information on the AT commands used please see the u-connect AT commands manual [1].

☞ Having a Central node connected to several Peripherals can automatically reduce MTU size to a minimum and severely impact throughput—depending on the product and the number of links.

☞ All tests have been performed with the Central node set up with only one Peripheral connection (default).

☞ If nothing else is stated, all measurements shown in this document have been taken with Serial Port Service (SPS) flow control enabled (default). SPS flow control can be only disabled using the u-blox app or through your own SPS implementation.

3 Throughput results for NINA-B1 v3.0.1 software

NINA-B1 SW version 3.0.1 is not capable of running 2 Mbit/s PHY.

3.1 Software versions

- ODIN-W2 software v4.0.0
- OBS421 software v5.3.2
- Android v7.0 with u-blox Bluetooth low energy app
- iOS v10.3.2 with u-blox Bluetooth low energy app

3.2 NINA-B1 (central) - NINA-B1 (peripheral)

Device A	Device B	Connection interval min, max (x * 1.25 ms)	MTU (bytes)	Dataflow	Throughput
NINA-B1 (central)	NINA-B1(peripheral)	6,6	23	Simplex	190 kbit/s
NINA-B1 (peripheral)	NINA-B1(central)	6,6	23	Simplex	190 kbit/s
NINA-B1 (central)	NINA-B1(peripheral)	6,6	23	Duplex	131 kbit/s
NINA-B1 (peripheral)	NINA-B1(central)	6,6	23	Duplex	131 kbit/s
NINA-B1 (central)	NINA-B1(peripheral)	24,40	247	Simplex	729 kbit/s
NINA-B1 (peripheral)	NINA-B1(central)	24,40	247	Simplex	729 kbit/s
NINA-B1 (central)	NINA-B1(peripheral)	24,40	247	Duplex	400 kbit/s
NINA-B1 (peripheral)	NINA-B1(central)	24,40	247	Duplex	400 kbit/s

3.3 ODIN-W2 (central) – NINA-B1 (peripheral)

Device A	Device B	Connection interval min, max (x * 1.25 ms)	MTU (bytes)	Dataflow	Throughput
ODIN-W2 (central)	NINA-B1 (peripheral)	6,6	23	Simplex	82 kbit/s
NINA-B1 (peripheral)	ODIN-W2 (central)	6,6	23	Simplex	31 kbit/s
ODIN-W2 (central)	NINA-B1 (peripheral)	6,6	23	Duplex	74 kbit/s
NINA-B1 (peripheral)	ODIN-W2 (central)	6,6	23	Duplex	16 kbit/s

3.4 ODIN-W2 (peripheral) – NINA-B1 (central)

Device A	Device B	Connection interval min, max (x * 1.25 ms)	MTU (bytes)	Dataflow	Throughput
NINA-B1 (central)	ODIN-W2 (peripheral)	6,6	23	Simplex	22 kbit/s
ODIN-W2 (peripheral)	NINA-B1(central)	6,6	23	Simplex	41 kbit/s
NINA-B1 (central)	ODIN-W2 (peripheral)	6,6	23	Duplex	9 kbit/s
ODIN-W2 (peripheral)	NINA-B1(central)	6,6	23	Duplex	36 kbit/s

3.5 OBS421 (central) – NINA-B1 (peripheral)

Device A	Device B	Connection interval min, max (x * 1.25 ms)	MTU (bytes)	Dataflow	Throughput
OBS421 (central)	NINA-B1 (peripheral)	6,40	23	Simplex	85 kbit/s
NINA-B1 (peripheral)	OBS421 (central)	6,40	23	Simplex	55 kbit/s
OBS421 (central)	NINA-B1 (peripheral)	6,40	23	Duplex	72 kbit/s
NINA-B1 (peripheral)	OBS421 (central)	6,40	23	Duplex	36 kbit/s

3.6 Android device (central) – NINA-B1 (peripheral)

Device A	Device B	Connection interval min, max (x * 1.25 ms)	MTU (bytes)	Dataflow	Throughput
Galaxy S8 (central)	NINA-B1 (peripheral)	12,12	23	Simplex	40 kbit/s
NINA-B1 (peripheral)	Galaxy S8 (central)	12,12	23	Simplex	76 kbit/s
Galaxy S8 (central)	NINA-B1 (peripheral)	12,12	23	Duplex	38 kbit/s
Galaxy S8 (central)	NINA-B1 (peripheral)	39,39	247	Simplex	470 kbit/s
NINA-B1 (peripheral)	Galaxy S8 (central)	39,39	247	Simplex	685 kbit/s
NINA-B1 (peripheral)	Galaxy S8 (central)	39,39	247	Duplex	319 kbit/s

3.7 iOS device (central) – NINA-B1 (peripheral)

Device A	Device B	Connection interval min, max (x * 1.25 ms)	MTU (bytes)	Dataflow	Throughput
iPhone 7 (central)	NINA-B1 (peripheral)	24,24	247	Simplex	194 kbit/s
NINA-B1 (peripheral)	iPhone 7 (central)	24,24	247	Simplex	182 kbit/s
iPhone 7 (central)	NINA-B1 (peripheral)	24,24	247	Duplex	68 kbit/s
NINA-B1 (peripheral)	iPhone 7 (central)	24,24	247	Duplex	74 kbit/s

☞ Preliminary tests of iPhone 7 with iOS 11 beta 2 shows a data throughput of ~350 kbit/s.

4 Throughput results for NINA-B1 v4.0.0 software

4.1 Software versions

- ODIN-W2 software v4.0.0
- OBS421 software v5.3.2
- Android v7.0 with u-blox Bluetooth low energy app
- iOS v11.0 with u-blox Bluetooth low energy app

4.2 NINA-B1 (central) - NINA-B1 (peripheral)

Device A	Device B	PHY	Connection interval min, max (x * 1.25 ms)	MTU (bytes)	Dataflow	Throughput
NINA-B1 (central)	NINA-B1(peripheral)	1 Mbps	6,6	23	Simplex	191 kbit/s
NINA-B1 (peripheral)	NINA-B1(central)	1 Mbps	6,6	23	Simplex	191 kbit/s
NINA-B1 (central)	NINA-B1(peripheral)	1 Mbps	6,6	23	Duplex	131 kbit/s
NINA-B1 (peripheral)	NINA-B1(central)	1 Mbps	6,6	23	Duplex	131 kbit/s
NINA-B1 (central)	NINA-B1(peripheral)	1 Mbps	24,40	247	Simplex	730 kbit/s
NINA-B1 (peripheral)	NINA-B1(central)	1 Mbps	24,40	247	Simplex	730 kbit/s
NINA-B1 (central)	NINA-B1(peripheral)	1 Mbps	24,40	247	Duplex	394 kbit/s
NINA-B1 (peripheral)	NINA-B1(central)	1 Mbps	24,40	247	Duplex	394 kbit/s
NINA-B1 (central)	NINA-B1(peripheral)	2 Mbps	6,6	23	Simplex	264 kbit/s
NINA-B1 (peripheral)	NINA-B1(central)	2 Mbps	6,6	23	Simplex	265 kbit/s
NINA-B1 (central)	NINA-B1(peripheral)	2 Mbps	6,6	23	Duplex	164 kbit/s
NINA-B1 (peripheral)	NINA-B1(central)	2 Mbps	6,6	23	Duplex	164 kbit/s
NINA-B1 (central)	NINA-B1(peripheral)	2 Mbps	6,6	247	Simplex	780 kbit/s
NINA-B1 (peripheral)	NINA-B1(central)	2 Mbps	6,6	247	Simplex	780 kbit/s
NINA-B1 (central)	NINA-B1(peripheral)	2 Mbps	24,40	247	Duplex	764 kbit/s
NINA-B1 (peripheral)	NINA-B1(central)	2 Mbps	24,40	247	Duplex	764 kbit/s

4.3 ODIN-W2 (central) – NINA-B1 (peripheral)

Device A	Device B	Connection interval min, max (x * 1.25 ms)	MTU (bytes)	Dataflow	Throughput
ODIN-W2 (central)	NINA-B1 (peripheral)	6,6	23	Simplex	82 kbit/s
NINA-B1 (peripheral)	ODIN-W2 (central)	6,6	23	Simplex	31 kbit/s
ODIN-W2 (central)	NINA-B1 (peripheral)	6,6	23	Duplex	74 kbit/s
NINA-B1 (peripheral)	ODIN-W2 (central)	6,6	23	Duplex	17 kbit/s

4.4 ODIN-W2 (peripheral) – NINA-B1 (central)

Device A	Device B	Connection interval min, max (x * 1.25 ms)	MTU (bytes)	Dataflow	Throughput
NINA-B1 (central)	ODIN-W2 (peripheral)	6,6	23	Simplex	22 kbit/s
ODIN-W2 (peripheral)	NINA-B1(central)	6,6	23	Simplex	42 kbit/s
NINA-B1 (central)	ODIN-W2 (peripheral)	6,6	23	Duplex	10 kbit/s
ODIN-W2 (peripheral)	NINA-B1(central)	6,6	23	Duplex	36 kbit/s

4.5 OBS421 (central) – NINA-B1 (peripheral)

Device A	Device B	Connection interval min, max (x * 1.25 ms)	MTU (bytes)	Dataflow	Throughput
OBS421 (central)	NINA-B1 (peripheral)	6,40	23	Simplex	85 kbit/s
NINA-B1 (peripheral)	OBS421 (central)	6,40	23	Simplex	56 kbit/s
OBS421 (central)	NINA-B1 (peripheral)	6,40	23	Duplex	72 kbit/s
NINA-B1 (peripheral)	OBS421 (central)	6,40	23	Duplex	36 kbit/s

4.6 Android device (central) – NINA-B1 (peripheral)

Device A	Device B	PHY	Connection interval min, max (x * 1.25 ms)	MTU (bytes)	Dataflow	Throughput
Galaxy S8 (central)	NINA-B1 (peripheral)	1 Mbps	6,40	23	Simplex	32 kbit/s
NINA-B1 (peripheral)	Galaxy S8 (central)	1 Mbps	6,40	23	Simplex	54 kbit/s
Galaxy S8 (central)	NINA-B1 (peripheral)	1 Mbps	6,40	23	Duplex	32 kbit/s
Galaxy S8 (central)	NINA-B1 (peripheral)	1 Mbps	6,40	247	Simplex	395 kbit/s
NINA-B1 (peripheral)	Galaxy S8 (central)	1 Mbps	6,40	247	Simplex	614 kbit/s
Galaxy S8 (central)	NINA-B1 (peripheral)	2 Mbps	6,40	23	Simplex	33 kbit/s
NINA-B1 (peripheral)	Galaxy S8 (central)	2 Mbps	6,40	23	Simplex	55 kbit/s
Galaxy S8 (central)	NINA-B1 (peripheral)	2 Mbps	6,40	23	Duplex	33 kbit/s
Galaxy S8 (central)	NINA-B1 (peripheral)	2 Mbps	6,6	247	Simplex	486 kbit/s
NINA-B1 (peripheral)	Galaxy S8 (central)	2 Mbps	6,6	247	Simplex	589 kbit/s

4.7 iOS device (central) – NINA-B1 (peripheral)

Device A	Device B	Connection interval min, max (x * 1.25 ms)	MTU (bytes)	Dataflow	Throughput
iPhone 7 (central)	NINA-B1 (peripheral)	6,40	23	Simplex	43 kbit/s
NINA-B1 (peripheral)	iPhone 7 (central)	6,40	23	Simplex	40 kbit/s
iPhone 7 (central)	NINA-B1 (peripheral)	6,40	23	Duplex	25 kbit/s
NINA-B1 (peripheral)	iPhone 7 (central)	6,40	23	Duplex	25 kbit/s
iPhone 7 (central)	NINA-B1 (peripheral)	12,12	247	Simplex	378 kbit/s
NINA-B1 (peripheral)	iPhone 7 (central)	12,12	247	Simplex	357 kbit/s
iPhone 7 (central)	NINA-B1 (peripheral)	40,320	247	Duplex	126 kbit/s
NINA-B1 (peripheral)	iPhone 7 (central)	40,320	247	Duplex	146 kbit/s

5 Throughput results for NINA-B1 v5.0.x and ANNA-B112 v2.0.x software

ANNA-B112 and NINA-B112 modules are not measured separately, as they are based on the same chipset and software. The relationship between the different ANNA-B112 and NINA-B1 software versions is described in chapter 1.

5.1 Software versions

- ODIN-W2 software v6.0.0
- NINA-B1 software v5.0.
- NINA-B3 software v1.0
- Samsung Galaxy S8 with u-blox Bluetooth low energy app
- iPhone 8 with u-blox Bluetooth low energy app

5.2 NINA-B1 – NINA-B1, simplex

Device A	Device B	PHY	MTU	Result (incl. conn.int (x * 1.25 ms))
DUT (central)	DUT (peripheral)	1M	23	191 kbit/s (6,6)
DUT (central)	DUT (peripheral)	1M	247	261 kbit/s (6,6) 743 kbit/s (24,40)
DUT (central)	DUT (peripheral)	2M	247	782 kbit/s (6,6) 624 kbit/s (24,40)

5.3 NINA-B1 – NINA-B1, duplex

Device A	Device B	PHY	MTU	Result (incl. conn.int (x * 1.25 ms))
DUT (central)	DUT (peripheral)	1M	23	130 kbit/s (6,6) 26 kbit/s (24,40)
DUT (peripheral)	DUT (central)	1M	23	130 kbit/s (6,6) 25 kbit/s (24,40)
DUT (central)	DUT (peripheral)	1M	247	232 kbit/s (6,6) 401 kbit/s (24,40)
DUT (peripheral)	DUT (central)	1M	247	231 kbit/s (6,6) 399 kbit/s (24,40)
DUT (central)	DUT (peripheral)	2M	23	176 kbit/s (6,6) 103 kbit/s (24,40)
DUT (peripheral)	DUT (central)	2M	23	179 kbit/s (6,6) 109 kbit/s (24,40)
DUT (central)	DUT (peripheral)	2M	247	595 kbit/s (6,6) 766 kbit/s (24,40)
DUT (peripheral)	DUT (central)	2M	247	590 kbit/s (6,6) 749 kbit/s (24,40)

5.4 NINA-B1 – NINA-B3, simplex

Device A	Device B	PHY	MTU	Result (incl. conn.int (x * 1.25 ms))
DUT (central)	NINA-B3 (peripheral)	1M	247	741 kbit/s (24,40)
DUT (peripheral)	NINA-B3 (central)	1M	247	741 kbit/s (24,40)
DUT (central)	NINA-B3 (peripheral)	2M	247	782 kbit/s (24,40)
DUT (peripheral)	NINA-B3 (central)	2M	247	782 kbit/s (24,40)

5.5 NINA-B1 – NINA-B3, duplex

Device A	Device B	PHY	MTU	Result (incl. conn.int (x * 1.25 ms))
DUT (central)	NINA-B3 (peripheral)	1M	247	396 kbit/s (24,40)
DUT (peripheral)	NINA-B3 (central)	1M	247	401 kbit/s (24,40)
DUT (central)	NINA-B3 (peripheral)	2M	247	726 kbit/s (24,40)
DUT (peripheral)	NINA-B3 (central)	2M	247	762 kbit/s (24,40)

5.6 NINA-B1 – ODIN-W2, simplex

Device A	Device B	PHY	MTU	Result (incl. conn.int (x * 1.25 ms))
DUT (peripheral)	ODIN-W2 (central)	1M	23	95 kbit/s (6,6)
DUT (central)	ODIN-W2 (peripheral)	1M	23	83 kbit/s (6,6)

5.7 NINA-B1 – ODIN-W2, duplex

Device A	Device B	PHY	MTU	Result (incl. conn.int (x * 1.25 ms))
ODIN-W2 (central)	DUT (peripheral)	1M	23	67 kbit/s (6,6)
DUT (peripheral)	ODIN-W2 (central)	1M	23	53 kbit/s (6,6)
ODIN-W2 (peripheral)	DUT (central)	1M	23	59 kbit/s (6,6)
DUT (central)	ODIN-W2 (peripheral)	1M	23	76 kbit/s (6,6)

5.8 NINA-B1 – iOS, simplex

Device A	Device B	PHY	MTU	Result (incl. conn.int (x * 1.25 ms))
iOS (central)	DUT (peripheral)	1M	23	42 kbit/s (24,40)
DUT (peripheral)	iOS (central)	1M	23	42 kbit/s (24,40)
iOS (central)	DUT (peripheral)	1M	247	173 kbit/s (24,40)
DUT (peripheral)	iOS (central)	1M	247	125 kbit/s (24,40)
iOS (central)	DUT (peripheral)	2M	23	60 kbit/s (24,40)
DUT (peripheral)	iOS (central)	2M	23	63 kbit/s (24,40)
iOS (central)	DUT (peripheral)	2M	247	263 kbit/s (24,40)
DUT (peripheral)	iOS (central)	2M	247	253 kbit/s (24,40)

5.9 NINA-B1 – iOS, duplex

Device A	Device B	PHY	MTU	Result (incl. conn.int (x * 1.25 ms))
iOS (central)	DUT (peripheral)	1M	23	35 kbit/s (24,40)
DUT (peripheral)	iOS (central)	1M	23	33 kbit/s (24,40)
iOS (central)	DUT (peripheral)	1M	247	73 kbit/s (24,40)
DUT (peripheral)	iOS (central)	1M	247	66 kbit/s (24,40)
iOS (central)	DUT (peripheral)	2M	23	45 kbit/s (24,40)
DUT (peripheral)	iOS (central)	2M	23	53 kbit/s (24,40)
iOS (central)	DUT (peripheral)	2M	247	165 kbit/s (24,40)
DUT (peripheral)	iOS (central)	2M	247	164 kbit/s (24,40)

5.10 NINA-B1 – Android device, simplex

Device A	Device B	PHY	MTU	Result (incl. conn.int (x * 1.25 ms))
Android (central)	DUT (peripheral)	1M	23	26 kbit/s (24,40)
DUT (peripheral)	Android (central)	1M	23	29 kbit/s (24,40)
Android (central)	DUT (peripheral)	1M	247	373 kbit/s (24,40)
DUT (peripheral)	Android (central)	1M	247	702 kbit/s (24,40)
DUT (peripheral)	Android (central)	2M	23	40 kbit/s (24,40)
Android (central)	DUT (peripheral)	2M	247	307 kbit/s (24,40)
DUT (peripheral)	Android (central)	2M	247	777 kbit/s (24,40)

5.11 NINA-B1 – Android device, duplex

Device A	Device B	PHY	MTU	Result (incl. conn.int (x * 1.25 ms))
Android (central)	DUT (peripheral)	1M	23	21 kbit/s (24,40)
DUT (peripheral)	Android (central)	1M	23	21 kbit/s (24,40)
Android (central)	DUT (peripheral)	1M	247	383 kbit/s (24,40)
DUT (peripheral)	Android (central)	1M	247	392 kbit/s (24,40)
Android (central)	DUT (peripheral)	2M	23	26 kbit/s (24,40)
DUT (peripheral)	Android (central)	2M	23	32 kbit/s (24,40)
Android (central)	DUT (peripheral)	2M	247	327 kbit/s (24,40)
DUT (peripheral)	Android (central)	2M	247	608 kbit/s (24,40)

6 Throughput results for NINA-B3 v2.0.x software

6.1 Software versions

- ODIN-W2 software v6.0.0
- NINA-B1 software v4.0.
- Android v9.0 with u-blox Bluetooth low energy app
- iOS v12.1.2 with u-blox Bluetooth low energy app

In this chapter the DUT = NINA-B3 SW 2.0.0.

6.2 NINA-B3 - NINA-B3, simplex

Device A	Device B	PHY	MTU	Result (incl. conn.int (x * 1.25 ms))
DUT (central)	DUT (peripheral)	1M	23	191 kbit/s (6,6) 26 kbit/s (24,40)
DUT (central)	DUT (peripheral)	1M	247	261 kbit/s (6,6) 741 kbit/s (24,40)
DUT (central)	DUT (peripheral)	2M	23	276 kbit/s (6,6) 227 kbit/s (24,40)
DUT (central)	DUT (peripheral)	2M	247	782 kbit/s (6,6) 625 kbit/s (24,40)

6.3 NINA-B3 - NINA-B3, duplex

Device A	Device B	PHY	MTU	Result (incl. conn.int (x * 1.25 ms))
DUT (central)	DUT (peripheral)	1M	23	130 kbit/s (6,6) 26 kbit/s (24,40)
DUT (peripheral)	DUT (central)	1M	23	129 kbit/s (6,6) 25 kbit/s (24,40)
DUT (central)	DUT (peripheral)	1M	247	232 kbit/s (6,6) 401 kbit/s (24,40)
DUT (peripheral)	DUT (central)	1M	247	231 kbit/s (6,6) 399 kbit/s (24,40)
DUT (central)	DUT (peripheral)	2M	23	175 kbit/s (6,6) 105 kbit/s (24,40)
DUT (peripheral)	DUT (central)	2M	23	178 kbit/s (6,6) 110 kbit/s (24,40)
DUT (central)	DUT (peripheral)	2M	247	596 kbit/s (6,6) 763 kbit/s (24,40)
DUT (peripheral)	DUT (central)	2M	247	590 kbit/s (6,6) 754 kbit/s (24,40)

6.4 NINA-B3 - NINA-B1, simplex

Device A	Device B	PHY	MTU	Result (incl. conn.int (x * 1.25 ms))
DUT (central)	NINA-B1 (peripheral)	1M	247	576 kbit/s (24,40)
NINA-B1 (central)	DUT (peripheral)	1M	247	613 kbit/s (24,40)
DUT (central)	NINA-B1 (peripheral)	2M	247	780 kbit/s (6,6)
NINA-B1 (central)	DUT (peripheral)	2M	247	780 kbit/s (6,6)

6.5 NINA-B3 - NINA-B1, duplex

Device A	Device B	PHY	MTU	Result (incl. conn.int (x * 1.25 ms))
DUT (central)	NINA-B1 (peripheral)	1M	247	319 kbit/s (24,40)
NINA-B1 (peripheral)	DUT (central)	1M	247	318 kbit/s (24,40)
DUT (peripheral)	NINA-B1 (central)	1M	247	331 kbit/s (24,40)
NINA-B1 (central)	DUT (peripheral)	1M	247	332 kbit/s (24,40)
DUT (central)	NINA-B1 (peripheral)	2M	247	508 kbit/s (24,40)
NINA-B1 (peripheral)	DUT (central)	2M	247	504 kbit/s (24,40)
DUT (peripheral)	NINA-B1 (central)	2M	247	512 kbit/s (24,40)
NINA-B1 (central)	DUT (peripheral)	2M	247	517 kbit/s (24,40)

6.6 NINA-B3 – ODIN-W2, simplex

Device A	Device B	PHY	MTU	Result (incl. conn.int (x * 1.25 ms))
ODIN-W2 (central)	DUT (peripheral)	1M	23	82 kbit/s (6,6)
DUT (peripheral)	ODIN-W2 (central)	1M	23	83 kbit/s (6,6)

6.7 NINA-B3 – ODIN-W2, duplex

Device A	Device B	PHY	MTU	Result (incl. conn.int (x * 1.25 ms))
ODIN-W2 (central)	DUT (peripheral)	1M	23	45 kbit/s (6,6)
DUT (peripheral)	ODIN-W2 (central)	1M	23	68 kbit/s (6,6)

6.8 NINA-B3 – iOS, simplex

Device A	Device B	PHY	MTU	Result (conn.int. factory default (x * 1.25 ms))
iOS (central)	DUT (peripheral)	1M	23	42 kbit/s (24,40)
DUT (peripheral)	iOS (central)	1M	23	47 kbit/s (24,40)
iOS (central)	DUT (peripheral)	1M	247	192 kbit/s (24,40)
DUT (peripheral)	iOS (central)	1M	247	188 kbit/s (24,40)
iOS (central)	DUT (peripheral)	2M	23	56 kbit/s (24,40)
DUT (peripheral)	iOS (central)	2M	23	62 kbit/s (24,40)
iOS (central)	DUT (peripheral)	2M	247	323 kbit/s (24,40)
DUT (peripheral)	iOS (central)	2M	247	314 kbit/s (24,40)

6.9 NINA-B3 – iOS, duplex

Device A	Device B	PHY	MTU	Result (conn.int. factory default (x * 1.25 ms))
iOS (central)	DUT (peripheral)	1M	23	33 kbit/s (24,40)
DUT (peripheral)	iOS (central)	1M	23	33 kbit/s (24,40)
iOS (central)	DUT (peripheral)	1M	247	71 kbit/s (24,40)
DUT (peripheral)	iOS (central)	1M	247	67 kbit/s (24,40)
iOS (central)	DUT (peripheral)	2M	23	46 kbit/s (24,40)
DUT (peripheral)	iOS (central)	2M	23	52 kbit/s (24,40)
iOS (central)	DUT (peripheral)	2M	247	183 kbit/s (24,40)
DUT (peripheral)	iOS (central)	2M	247	166 kbit/s (24,40)

6.10 NINA-B3 – Android device, simplex

Device A	Device B	PHY	MTU	Result (conn.int. factory default (x * 1.25 ms))
Android (central)	DUT (peripheral)	1M	23	26 kbit/s (24,40)
DUT (peripheral)	Android (central)	1M	23	150 kbit/s (24,40)
Android (central)	DUT (peripheral)	1M	247	670 kbit/s (24,40)
DUT (peripheral)	Android (central)	1M	247	708 kbit/s (24,40)
Android (central)	DUT (peripheral)	2M	23	26 kbit/s (24,40)
DUT (peripheral)	Android (central)	2M	23	100 kbit/s (24,40)
Android (central)	DUT (peripheral)	2M	247	364 kbit/s (24,40)
DUT (peripheral)	Android (central)	2M	247	768 kbit/s (24,40)

6.11 NINA-B3 – Android device, duplex

Device A	Device B	PHY	MTU	Result (conn.int. factory default (x * 1.25 ms))
Android (central)	DUT (peripheral)	1M	23	45 kbit/s (24,40)
DUT (peripheral)	Android (central)	1M	23	172 kbit/s (24,40)
Android (central)	DUT (peripheral)	1M	247	408 kbit/s (24,40)
DUT (peripheral)	Android (central)	1M	247	392 kbit/s (24,40)
Android (central)	DUT (peripheral)	2M	23	52 kbit/s (24,40)
DUT (peripheral)	Android (central)	2M	23	172 kbit/s (24,40)
Android (central)	DUT (peripheral)	2M	247	730 kbit/s (24,40)
DUT (peripheral)	Android (central)	2M	247	750 kbit/s (24,40)

7 Throughput results for NINA-B3 v3.0.x software

7.1 SW versions

- NINA-B1 SW 6.0.0
- NINA-B31X-3.0.0
- ANNA-B112-3.0.0
- iPhone8
- Galaxy S9

7.2 NINA-B3-NINA-B3, simplex

Device A	Device B	PHY	MTU	Result (conn.int. x * 1.25 ms)
NINA-B3 (central)	NINA-B3 (peripheral)	1M	247	260 kbps (6,6) 733 kbps (24,40)
NINA-B3 (central)	NINA-B3 (peripheral)	2M	247	781 kbps (6,6)

7.3 NINA-B3-NINA-B3, duplex

Device A	Device B	PHY	MTU	Result (conn.int. x * 1.25 ms)
NINA-B3 (central)	NINA-B3 (peripheral)	1M	247	tx: 245 kbps (6,6) rx: 245 kbps (6,6)
NINA-B3 (central)	NINA-B3 (peripheral)	2M	247	tx: 555 kbps (6,6) rx: 555 kbps (6,6)

7.4 NINA-B3 – NINA-B1, simplex

Device A	Device B	PHY	MTU	Result (conn.int. x * 1.25 ms)
NINA-B3 (central)	NINA-B1 (peripheral)	1M	247	740 kbit/s (24,40)
NINA-B3 (central)	NINA-B1 (peripheral)	1M	247	256 kbit/s (6,6)
NINA-B1 (central)	NINA-B3 (peripheral)	1M	247	687 kbit/s (24,40)
NINA-B1 (central)	NINA-B3 (peripheral)	1M	247	260 kbit/s (6,6)
NINA-B3 (central)	NINA-B1 (peripheral)	2M	247	782 kbit/s (6,6)
NINA-B1 (central)	NINA-B3 (peripheral)	2M	247	783 kbit/s (6,6)

7.5 NINA-B3 – NINA-B1, duplex

Device A	Device B	PHY	MTU	Result (conn.int. x * 1.25 ms)
NINA-B3 (central)	NINA-B1 (peripheral)	1M	247	391 kbit/s (24,40)
NINA-B1 (central)	NINA-B3 (peripheral)	1M	247	390 kbit/s (24,40)
NINA-B3 (central)	NINA-B1 (peripheral)	2M	247	679 kbit/s (24,40)
NINA-B1 (central)	NINA-B3 (peripheral)	2M	247	667 kbit/s (6,6)

7.6 NINA-B3 – ODIN-W26, simplex

Device A	Device B	PHY	MTU	Result (conn.int. x * 1.25 ms)
NINA-B3 (central)	ODIN-W26 (peripheral)	1M	23	95 kbps (6,6)
NINA-B3 (peripheral)	ODIN-W26 (central)	1M	23	82 kbps (6,6)

7.7 NINA-B3 – ODIN-W26, duplex

Device A	Device B	PHY	MTU	Result (conn.int. x * 1.25 ms)
NINA-B3 (central)	ODIN-W26 (peripheral)	1M	23	tx: 69 kbps (6,6) rx: 63 kbps (6,6)
NINA-B3 (peripheral)	ODIN-W26 (central)	1M	23	tx: 66 kbps (6,6) rx: 63 kbps (6,6)

7.8 Android - NINA-B3, simplex

Device A	Device B	PHY	MTU	Result (conn.int. x * 1.25 ms)
Android (central)	NINA-B3 (peripheral)	1M	23	121 kbps (24,40)
NINA-B3 (peripheral)	Android (central)	1M	23	216 kbps (24,40)
Android (central)	NINA-B3 (peripheral)	1M	247	538 kbps (24,40)
NINA-B3 (peripheral)	Android (central)	1M	247	654 kbps (24,40)
Android (central)	NINA-B3 (peripheral)	2M	247	587 kbps (24,40)
NINA-B3 (peripheral)	Android (central)	2M	247	614 kbps (24,40)

7.9 Android - NINA-B3, duplex

Device A	Device B	PHY	MTU	Result (conn.int. x * 1.25 ms)
Android (central)	NINA-B3 (peripheral)	1M	23	140 kbps (24,40)
NINA-B3 (peripheral)	Android (central)	1M	23	174 kbps (24,40)
Android (central)	NINA-B3 (peripheral)	1M	247	405 kbps (24,40)
NINA-B3 (peripheral)	Android (central)	1M	247	394 kbps (24,40)
Android (central)	NINA-B3 (peripheral)	2M	247	770 kbps (24,40)
NINA-B3 (peripheral)	Android (central)	2M	247	763 kbps (24,40)

7.10 iOS - NINA-B3, simplex

Device A	Device B	PHY	MTU	Result (conn.int. x * 1.25 ms)
iOS (central)	NINA-B3 (peripheral)	1M	23	48 kbps (24,40)
NINA-B3 (peripheral)	iOS (central)	1M	23	48 kbps (24,40)
iOS (central)	NINA-B3 (peripheral)	1M	247	193 kbps (24,40)
NINA-B3 (peripheral)	iOS (central)	1M	247	180 kbps (24,40)
iOS (central)	NINA-B3 (peripheral)	2M	247	263 kbps (24,40)
NINA-B3 (peripheral)	iOS (central)	2M	247	257 kbps (24,40)

7.11 iOS - NINA-B3, duplex

Device A	Device B	PHY	MTU	Result (conn.int. x * 1.25 ms)
iOS (central)	NINA-B3 (peripheral)	1M	23	35 kbps (24,40)
NINA-B3 (peripheral)	iOS (central)	1M	23	35 kbps (24,40)
iOS (central)	NINA-B3 (peripheral)	1M	247	69 kbps (24,40)
NINA-B3 (peripheral)	iOS (central)	1M	247	69 kbps (24,40)
iOS (central)	NINA-B3 (peripheral)	2M	247	160 kbps (24,40)
NINA-B3 (peripheral)	iOS (central)	2M	247	160 kbps (24,40)

8 Throughput results for NINA-B1 SW 6.0/ ANNA-B1 v3.0 software

8.1 SW versions

- NINA-B1 SW 6.0.0
- NINA-B31X-3.0.0
- ANNA-B112-3.0.0
- iPhone8
- Galaxy S9

8.2 NINA-B1-NINA-B1, simplex

Device A	Device B	PHY	MTU	Result (conn.int. x * 1.25 ms)
NINA-B1 (central)	NINA-B1 (peripheral)	1M	247	261 kbps (6,6) 733 kbps (24,40)
NINA-B1 (central)	NINA-B1 (peripheral)	2M	247	778 kbps (6,6)

8.3 NINA-B1-NINA-B1, duplex

Device A	Device B	PHY	MTU	Result (conn.int. x * 1.25 ms)
NINA-B1 (central)	NINA-B1 (peripheral)	1M	247	tx: 231 kbps (6,6) rx: 232 kbps (6,6)

8.4 NINA-B1 – NINA-B3, simplex

Device A	Device B	PHY	MTU	Result (conn.int. x * 1.25 ms)
NINA-B1 (central)	NINA-B3 (peripheral)	1M	247	725 kbit/s (24,40)
NINA-B1 (central)	NINA-B3 (peripheral)	1M	247	256 kbit/s (6,6)
NINA-B3 (central)	NINA-B1 (peripheral)	1M	247	667 kbit/s (24,40)
NINA-B3 (central)	NINA-B1 (peripheral)	1M	247	258 kbit/s (6,6)

8.5 NINA-B1 – NINA-B3, duplex

Device A	Device B	PHY	MTU	Result (conn.int. x * 1.25 ms)
NINA-B1 (central)	NINA-B3 (peripheral)	1M	247	tx: 227 kbps (6,6) rx: 226 kbps (6,6) tx: 373 kbps (24,40) rx: 373 kbps (24,40)
NINA-B3 (central)	NINA-B1 (peripheral)	1M	247	tx: 227 kbps (6,6) rx: 227 kbps (6,6) tx: 388 kbps (24,40) rx: 388 kbps (24,40)

8.6 NINA-B1 – ODIN-W26, simplex

Device A	Device B	PHY	MTU	Result (conn.int. x * 1.25 ms)
NINA-B1 (central)	ODIN-W26 (peripheral)	1M	23	953kbps (6,6)
NINA-B1 (peripheral)	ODIN-W26 (central)	1M	23	82 kbps (6,6)

8.7 NINA-B1 – ODIN-W26, duplex

Device A	Device B	PHY	MTU	Result (conn.int. x * 1.25 ms)
NINA-B1 (central)	ODIN-W26 (peripheral)	1M	23	tx: 69 kbps (6,6) rx: 51 kbps (6,6)
NINA-B1 (peripheral)	ODIN-W26 (central)	1M	23	tx: 68 kbps (6,6) rx: 48 kbps (6,6)

8.8 Android - NINA-B1, simplex

Device A	Device B	PHY	MTU	Result (conn.int. x * 1.25 ms)
Android (central)	NINA-B1 (peripheral)	1M	23	26 kbps (24,40)
NINA-B1 (peripheral)	Android (central)	1M	23	28 kbps (24,40)
Android (central)	NINA-B1 (peripheral)	1M	247	548 kbps (24,40)
NINA-B1 (peripheral)	Android (central)	1M	247	659 kbps (24,40)
Android (central)	NINA-B1 (peripheral)	2M	247	355 kbps (24,40)
NINA-B1 (peripheral)	Android (central)	2M	247	698 kbps (24,40)

8.9 Android - NINA-B1, duplex

Device A	Device B	PHY	MTU	Result (conn.int. x * 1.25 ms)
Android (central)	NINA-B1 (peripheral)	1M	23	19 kbps (24,40)
NINA-B1 (peripheral)	Android (central)	1M	23	20 kbps (24,40)
Android (central)	NINA-B1 (peripheral)	1M	247	119 kbps (24,40)
NINA-B1 (peripheral)	Android (central)	1M	247	621 kbps (24,40)
Android (central)	NINA-B1 (peripheral)	2M	247	170 kbps (24,40)
NINA-B1 (peripheral)	Android (central)	2M	247	623 kbps (24,40)

8.10 iOS - NINA-B1, simplex

Device A	Device B	PHY	MTU	Result (conn.int. x * 1.25 ms)
iOS (central)	NINA-B1 (peripheral)	1M	23	43 kbps (24,40)
NINA-B1 (peripheral)	iOS (central)	1M	23	48 kbps (24,40)
iOS (central)	NINA-B1 (peripheral)	1M	247	193 kbps (24,40)
NINA-B1 (peripheral)	iOS (central)	1M	247	192 kbps (24,40)
iOS (central)	NINA-B1 (peripheral)	2M	247	266 kbps (24,40)
NINA-B1 (peripheral)	iOS (central)	2M	247	259 kbps (24,40)

8.11 iOS - NINA-B1, duplex

Device A	Device B	PHY	MTU	Result (conn.int. x * 1.25 ms)
iOS (central)	NINA-B1 (peripheral)	1M	23	35 kbps (24,40)
NINA-B1 (peripheral)	iOS (central)	1M	23	31 kbps (24,40)

Device A	Device B	PHY	MTU	Result (conn.int. x * 1.25 ms)
iOS (central)	NINA-B1 (peripheral)	1M	247	72 kbps (24,40)
NINA-B1 (peripheral)	iOS (central)	1M	247	68 kbps (24,40)
iOS (central)	NINA-B1 (peripheral)	2M	247	162 kbps (24,40)
NINA-B1 (peripheral)	iOS (central)	2M	247	162 kbps (24,40)

9 Throughput results for NINA-B2 v1.0.x software

9.1 Software versions

- ODIN-W2 software v6.0.0
- NINA-B1 software v4.0.1 (unofficial)
- Samsung Galaxy S8 with u-blox Bluetooth low energy app
- iPhone 8 with u-blox Bluetooth low energy app

In this chapter the DUT = NINA-B2 SW 1.0.0.

9.2 NINA-B2 – NINA-B2, simplex

Device A	Device B	PHY	MTU	Result (including connection interval)
DUT (central)	DUT (peripheral)	1M	23	95 (7.5 ms)
DUT (peripheral)	DUT (central)	1M	23	94 (7.5 ms)
DUT (central)	DUT (peripheral)	1M	247	385 (16.25 ms)
DUT (peripheral)	DUT (central)	1M	247	388 (16.25 ms)
DUT (central)	DUT (peripheral)	2M	23	N/A
DUT (peripheral)	DUT (central)	2M	23	N/A
DUT (central)	DUT (peripheral)	2M	247	N/A
DUT (peripheral)	DUT (central)	2M	247	N/A

9.3 NINA-B2 – NINA-B2, duplex

Device A	Device B	PHY	MTU	Result (including connection interval)
DUT (central)	DUT (peripheral)	1M	23	56 (7.5 ms)
DUT (peripheral)	DUT (central)	1M	23	81 (7.5 ms)
DUT (central)	DUT (peripheral)	1M	247	212 (25 ms)
DUT (peripheral)	DUT (central)	1M	247	210 (25 ms)
DUT (central)	DUT (peripheral)	2M	23	N/A
DUT (peripheral)	DUT (central)	2M	23	N/A
DUT (central)	DUT (peripheral)	2M	247	N/A
DUT (peripheral)	DUT (central)	2M	247	N/A

9.4 NINA-B2 – NINA-B1, simplex

Device A	Device B	PHY	MTU	Result (including connection interval)
DUT (central)	NINA-B1 (peripheral)	1M	23	50 (7.5 ms)
DUT (peripheral)	NINA-B1 (central)	1M	23	124 (7.5 ms)
DUT (central)	NINA-B1 (peripheral)	1M	247	520 (18.75 ms)
DUT (peripheral)	NINA-B1 (central)	1M	247	540 (18.75 ms)
DUT (central)	NINA-B1 (peripheral)	2M	23	N/A
DUT (peripheral)	NINA-B1 (central)	2M	23	N/A
DUT (central)	NINA-B1 (peripheral)	2M	247	N/A
DUT (peripheral)	NINA-B1 (central)	2M	247	N/A

9.5 NINA-B2 – NINA-B1, duplex

Device A	Device B	PHY	MTU	Result (including connection interval)
DUT (central)	NINA-B1 (peripheral)	1M	23	30 (7.5 ms)
DUT (peripheral)	NINA-B1 (central)	1M	23	92 (18.5 ms)
DUT (central)	NINA-B1 (peripheral)	1M	247	263 (18.5 ms)
DUT (peripheral)	NINA-B1 (central)	1M	247	260 (18.75 ms)
DUT (central)	NINA-B1 (peripheral)	2M	23	N/A
DUT (peripheral)	NINA-B1 (central)	2M	23	N/A
DUT (central)	NINA-B1 (peripheral)	2M	247	N/A
DUT (peripheral)	NINA-B1 (central)	2M	247	N/A

9.6 NINA-B2 – ODIN-W2, simplex

Device A	Device B	PHY	MTU	Result (including connection interval)
ODIN-W2 (central)	DUT (peripheral)	1M	23	81 (7.5 ms)
DUT (peripheral)	ODIN-W2 (central)	1M	23	81 (7.5 ms)
ODIN-W2 (peripheral)	DUT (central)	1M	23	122 (7.5 ms)
DUT (central)	ODIN-W2 (peripheral)	1M	23	142 (7.5 ms)

9.7 NINA-B2 – ODIN-W2, duplex

Device A	Device B	PHY	MTU	Result (including connection interval)
ODIN-W2 (central)	DUT (peripheral)	1M	23	44 (7.5 ms)
DUT (peripheral)	ODIN-W2 (central)	1M	23	66 (7.5 ms)
ODIN-W2 (peripheral)	DUT (central)	1M	23	75 (7.5 ms)
DUT (central)	ODIN-W2 (peripheral)	1M	23	81 (7.5 ms)

9.8 NINA-B2 – iOS device, simplex

Device A	Device B	PHY	MTU	Result (including connection interval)
iOS (central)	DUT (peripheral)	1M	23	27 (7.5 ms)
DUT (peripheral)	iOS (central)	1M	23	27 (7.5 ms)
iOS (central)	DUT (peripheral)	1M	247	185 (30 ms)
DUT (peripheral)	iOS (central)	1M	247	131 (30 ms)
iOS (central)	DUT (peripheral)	2M	23	N/A
DUT (peripheral)	iOS (central)	2M	23	N/A
iOS (central)	DUT (peripheral)	2M	247	N/A
DUT (peripheral)	iOS (central)	2M	247	N/A

9.9 NINA-B2 – iOS device, duplex

Device A	Device B	PHY	MTU	Result (including connection interval)
iOS (central)	DUT (peripheral)	1M	23	22 (7.5 ms)
DUT (peripheral)	iOS (central)	1M	23	12 (7.5 ms)
iOS (central)	DUT (peripheral)	1M	182	65 (30 ms)
DUT (peripheral)	iOS (central)	1M	182	65 (30 ms)
iOS (central)	DUT (peripheral)	2M	23	N/A
DUT (peripheral)	iOS (central)	2M	23	N/A
iOS (central)	DUT (peripheral)	2M	247	N/A
DUT (peripheral)	iOS (central)	2M	247	N/A

9.10 NINA-B2 – Android device, simplex

Device A	Device B	PHY	MTU	Result (including connection interval)
Android (central)	DUT (peripheral)	1M	23	15 (7.5 ms) (High connection priority)
DUT (peripheral)	Android (central)	1M	23	122 (7.5 ms) (High connection priority)
Android (central)	DUT (peripheral)	1M	247	224 (7.5 ms) (High connection priority)
DUT (peripheral)	Android (central)	1M	247	442 (7.5 ms) (High connection priority)
Android (central)	DUT (peripheral)	2M	23	N/A
DUT (peripheral)	Android (central)	2M	23	N/A
Android (central)	DUT (peripheral)	2M	247	N/A
DUT (peripheral)	Android (central)	2M	247	N/A

9.11 NINA-B2 – Android device, duplex

Device A	Device B	PHY	MTU	Result (including connection interval)
Android (central)	DUT (peripheral)	1M	23	11 (7.5 ms) (High connection priority)
DUT (peripheral)	Android (central)	1M	23	121 (7.5 ms) (High connection priority)
Android (central)	DUT (peripheral)	1M	247	205 (7.5 ms) (High connection priority)
DUT (peripheral)	Android (central)	1M	247	328 (7.5 ms) (High connection priority)
Android (central)	DUT (peripheral)	2M	23	N/A
DUT (peripheral)	Android (central)	2M	23	N/A
Android (central)	DUT (peripheral)	2M	247	N/A
DUT (peripheral)	Android (central)	2M	247	N/A

10 Throughput results for NINA-B2 v2.1.x software

10.1 Software versions

- ODIN-W2 software v6.0.0
- NINA-B3 software v2.0.0
- Samsung Galaxy S8 with u-blox Bluetooth low energy app
- iPhone 8 with u-blox Bluetooth low energy app

In this chapter the DUT = NINA-B2 SW 2.1.0.

10.2 NINA-B2 – NINA-B2, simplex

Device A	Device B	PHY	MTU	Result (including connection interval)
DUT (central)	DUT (peripheral)	1M	23	95 kbit/s (6, 6)
DUT (central)	DUT (peripheral)	1M	247	230 kbit/s (24, 40)
DUT (central)	DUT (peripheral)	1M	247	507 kbit/s (6, 6)
DUT (central)	DUT (peripheral)	2M	23	N/A
DUT (central)	DUT (peripheral)	2M	247	N/A
DUT (peripheral)	DUT (central)	1M	23	N/A
DUT (peripheral)	DUT (central)	1M	247	N/A
DUT (peripheral)	DUT (central)	2M	23	N/A
DUT (peripheral)	DUT (central)	2M	247	N/A

Optimal configuration: Enable LL PDU payload size (Data Length Extension) and ATT MTU size negotiation, with Connection Interval 6, 6.

10.3 NINA-B2 – NINA-B2, duplex

Device A	Device B	PHY	MTU	Result (including connection interval)
DUT (central)	DUT (peripheral)	1M	23	58 kbit/s (6, 6)
DUT (peripheral)	DUT (central)	1M	23	89 kbit/s (6,6)
DUT (central)	DUT (peripheral)	1M	247	220 kbit/s (6, 6)
DUT (central)	DUT (peripheral)	1M	247	230 kbit/s (24, 40)
DUT (peripheral)	DUT (central)	1M	247	220 kbit/s (6, 6)
DUT (peripheral)	DUT (central)	1M	247	230 kbit/s (24, 40)
DUT (central)	DUT (peripheral)	2M	23	N/A
DUT (peripheral)	DUT (central)	2M	23	N/A
DUT (central)	DUT (peripheral)	2M	247	N/A
DUT (peripheral)	DUT (central)	2M	247	N/A

Optimal configuration: Enable LL PDU payload size (Data Length Extension) and ATT MTU size negotiation.

10.4 NINA-B2 – NINA-B3, simplex

Device A	Device B	PHY	MTU	Result (including connection interval)
DUT (central)	NINA-B3 (peripheral)	1M	23	47 kbit/s (6, 6)
DUT (central)	NINA-B3 (peripheral)	1M	23	47 kbit/s (24, 40)
DUT (peripheral)	NINA-B3 (central)	1M	23	108 kbit/s (6, 6)
DUT (peripheral)	NINA-B3 (central)	1M	23	23 kbit/s (24, 40)
DUT (central)	NINA-B3 (peripheral)	1M	247	526 kbit/s (6, 6)
DUT (central)	NINA-B3 (peripheral)	1M	247	560 kbit/s (24, 40)
DUT (peripheral)	NINA-B3 (central)	1M	247	272 kbit/s (6, 6)
DUT (peripheral)	NINA-B3 (central)	1M	247	TBD (15, 15)
DUT (peripheral)	NINA-B3 (central)	1M	247	230 kbit/s (24, 40)
DUT (central)	NINA-B3 (peripheral)	2M	23	N/A
DUT (peripheral)	NINA-B3 (central)	2M	23	N/A
DUT (central)	NINA-B3 (peripheral)	2M	247	N/A
DUT (peripheral)	NINA-B3 (central)	2M	247	N/A

Optimal configuration: Enable LL PDU payload size (Data Length Extension) and ATT MTU size negotiation.

10.5 NINA-B2 – NINA-B3, duplex

Device A	Device B	PHY	MTU	Result (including connection interval)
DUT (central)	NINA-B3 (peripheral)	1M	23	64 kbit/s (6, 6)
DUT (central)	NINA-B3 (peripheral)	1M	23	29 kbit/s (24, 40)
DUT (peripheral)	NINA-B3 (central)	1M	23	95 kbit/s (6, 6)
DUT (peripheral)	NINA-B3 (central)	1M	23	73 kbit/s (24, 40)
DUT (central)	NINA-B3 (peripheral)	1M	247	210 kbit/s (6, 6)
DUT (central)	NINA-B3 (peripheral)	1M	247	TBD (15, 15)
DUT (central)	NINA-B3 (peripheral)	1M	247	340 kbit/s (24, 40)
DUT (peripheral)	NINA-B3 (central)	1M	247	189 kbit/s (6, 6)
DUT (peripheral)	NINA-B3 (central)	1M	247	TBD (15, 15)
DUT (peripheral)	NINA-B3 (central)	1M	247	300 kbit/s (24, 40)
DUT (central)	NINA-B3 (peripheral)	2M	23	N/A
DUT (peripheral)	NINA-B3 (central)	2M	23	N/A
DUT (central)	NINA-B3 (peripheral)	2M	247	N/A
DUT (peripheral)	NINA-B3 (central)	2M	247	N/A

Optimal configuration: Enable LL PDU payload size (Data Length Extension) and ATT MTU size negotiation.

10.6 NINA-B2 – ODIN-W2, simplex

Device A	Device B	PHY	MTU	Result (including connection interval)
DUT (central)	ODIN-W2 (peripheral)	1M	23	110 kbit/s (6,6)
DUT (central)	ODIN-W2 (peripheral)	1M	23	28 kbit/s (24, 40)
DUT (peripheral)	ODIN-W2 (central)	1M	23	81 kbit/s (6,6)
DUT (peripheral)	ODIN-W2 (central)	1M	23	25 kbit/s (24, 40)

Optimal configuration: Use Connection Interval 6, 6.

10.7 NINA-B2 – ODIN-W2, duplex

Device A	Device B	PHY	MTU	Result (including connection interval)
DUT (central)	ODIN-W2 (peripheral)	1M	23	65 kbit/s (6, 6)
DUT (central)	ODIN-W2 (peripheral)	1M	23	22 kbit/s (24,40)
DUT (peripheral)	ODIN-W2 (central)	1M	23	53 kbit/s (6, 6)
DUT (peripheral)	ODIN-W2 (central)	1M	23	18 kbit/s (24,40)

Optimal configuration: Use Connection Interval 6, 6.

10.8 NINA-B2 – iOS device, simplex

Device A	Device B	PHY	MTU	Result (including connection interval)
iOS (central)	DUT (peripheral)	1M	23	TBD (6, 6)
iOS (central)	DUT (peripheral)	1M	182	145 kbit/s (6, 6)
iOS (central)	DUT (peripheral)	1M	247	TBD (24, 40)
DUT (peripheral)	iOS (central)	1M	23	TBD (6, 6)
DUT (peripheral)	iOS (central)	1M	182	133 kbit/s (6,6)
DUT (peripheral)	iOS (central)	1M	247	TBD (24, 40)
iOS (central)	DUT (peripheral)	2M	23	N/A
DUT (peripheral)	iOS (central)	2M	23	N/A
iOS (central)	DUT (peripheral)	2M	247	N/A
DUT (peripheral)	iOS (central)	2M	247	N/A

Optimal configuration: Enable LL PDU payload size (Data Length Extension) and ATT MTU size negotiation, with Connection Interval 6, 6.

10.9 NINA-B2 – iOS device, duplex

Device A	Device B	PHY	MTU	Result (including connection interval)
iOS (central)	DUT (peripheral)	1M	23	TBD (6, 6)
iOS (central)	DUT (peripheral)	1M	182	55 kbit/s (6, 6)
iOS (central)	DUT (peripheral)	1M	182	TBD (24, 40)
DUT (peripheral)	iOS (central)	1M	23	TBD (6,6)
DUT (peripheral)	iOS (central)	1M	182	101 kbit/s (6, 6)
DUT (peripheral)	iOS (central)	1M	182	TBD (24, 40)
iOS (central)	DUT (peripheral)	2M	23	N/A
DUT (peripheral)	iOS (central)	2M	23	N/A
iOS (central)	DUT (peripheral)	2M	247	N/A
DUT (peripheral)	iOS (central)	2M	247	N/A

Optimal configuration: Enable LL PDU payload size (Data Length Extension) and ATT MTU size negotiation, with Connection Interval 6, 6.

10.10 NINA-B2 – Android device, simplex

Device A	Device B	PHY	MTU	Result (including connection interval)
Android (central)	DUT (peripheral)	1M	23	TBD (6, 6) (High connection priority)
DUT (peripheral)	Android (central)	1M	23	TBD (6, 6) (High connection priority)
Android (central)	DUT (peripheral)	1M	247	285 kbit/s (6,6)
DUT (peripheral)	Android (central)	1M	247	650 kbit/s (6,6)
Android (central)	DUT (peripheral)	2M	23	N/A
DUT (peripheral)	Android (central)	2M	23	N/A
Android (central)	DUT (peripheral)	2M	247	N/A
DUT (peripheral)	Android (central)	2M	247	N/A

Optimal configuration: Enable LL PDU payload size (Data Length Extension) and ATT MTU size negotiation, with Connection Interval 6, 6.

10.11 NINA-B2 – Android device, duplex

Device A	Device B	PHY	MTU	Result (including connection interval)
Android (central)	DUT (peripheral)	1M	23	TBD (6, 6) (High connection priority)
DUT (peripheral)	Android (central)	1M	23	TBD (6, 6) (High connection priority)
Android (central)	DUT (peripheral)	1M	247	227 kbit/s (6, 6)
DUT (peripheral)	Android (central)	1M	247	390 kbit/s (6,6)
Android (central)	DUT (peripheral)	2M	23	N/A
DUT (peripheral)	Android (central)	2M	23	N/A
Android (central)	DUT (peripheral)	2M	247	N/A
DUT (peripheral)	Android (central)	2M	247	N/A

Optimal configuration: Enable LL PDU payload size (Data Length Extension) and ATT MTU size negotiation, with Connection Interval 6, 6.

11 Throughput results for NINA-W15 v2.1.x software

11.1 Software versions

- ODIN-W2 software v6.0.0
- NINA-B3 software v2.0.0
- Samsung Galaxy S8 with u-blox Bluetooth low energy app
- iPhone 8 with u-blox Bluetooth low energy app

In this chapter the DUT = NINA-W15 SW 2.1.0.

11.2 DUT – DUT, simplex

Device A	Device B	PHY	MTU	Result (including connection interval)
DUT (central)	DUT (peripheral)	1M	23	97 kbit/s (6, 6)
DUT (central)	DUT (peripheral)	1M	247	202 kbit/s (24, 40)
DUT (central)	DUT (peripheral)	1M	247	505 kbit/s (6, 6)
DUT (central)	DUT (peripheral)	2M	23	N/A
DUT (central)	DUT (peripheral)	2M	247	N/A

Optimal configuration: Enable LL PDU payload size (Data Length Extension) and ATT MTU size negotiation, with Connection Interval 6, 6.

11.3 DUT – DUT, duplex

Device A	Device B	PHY	MTU	Result (including connection interval)
DUT (central)	DUT (peripheral)	1M	23	60 kbit/s (6, 6)
DUT (peripheral)	DUT (central)	1M	23	92 kbit/s (6,6)
DUT (central)	DUT (peripheral)	1M	247	227 kbit/s (6, 6)
DUT (central)	DUT (peripheral)	1M	247	231 kbit/s (24, 40)
DUT (peripheral)	DUT (central)	1M	247	225 kbit/s (6, 6)
DUT (peripheral)	DUT (central)	1M	247	234 kbit/s (24, 40)
DUT (central)	DUT (peripheral)	2M	23	N/A
DUT (peripheral)	DUT (central)	2M	23	N/A
DUT (central)	DUT (peripheral)	2M	247	N/A
DUT (peripheral)	DUT (central)	2M	247	N/A

Optimal configuration: Enable LL PDU payload size (Data Length Extension) and ATT MTU size negotiation.

11.4 DUT – NINA-B3, simplex

Device A	Device B	PHY	MTU	Result (including connection interval)
DUT (central)	NINA-B3 (peripheral)	1M	23	47 kbit/s (6, 6)
DUT (central)	NINA-B3 (peripheral)	1M	23	46 kbit/s (24, 40)
DUT (peripheral)	NINA-B3 (central)	1M	23	108 kbit/s (6, 6)
DUT (peripheral)	NINA-B3 (central)	1M	23	21 kbit/s (24, 40)
DUT (central)	NINA-B3 (peripheral)	1M	247	522 kbit/s (6, 6)
DUT (central)	NINA-B3 (peripheral)	1M	247	550 kbit/s (24, 40)
DUT (peripheral)	NINA-B3 (central)	1M	247	265 kbit/s (6, 6)
DUT (peripheral)	NINA-B3 (central)	1M	247	TBD (15, 15)
DUT (peripheral)	NINA-B3 (central)	1M	247	227 kbit/s (24, 40)
DUT (central)	NINA-B3 (peripheral)	2M	23	N/A
DUT (peripheral)	NINA-B3 (central)	2M	23	N/A
DUT (central)	NINA-B3 (peripheral)	2M	247	N/A
DUT (peripheral)	NINA-B3 (central)	2M	247	N/A

Optimal configuration: Enable LL PDU payload size (Data Length Extension) and ATT MTU size negotiation.

11.5 DUT – NINA-B3, duplex

Device A	Device B	PHY	MTU	Result (including connection interval)
DUT (central)	NINA-B3 (peripheral)	1M	23	66 kbit/s (6, 6)
DUT (central)	NINA-B3 (peripheral)	1M	23	29 kbit/s (24, 40)
DUT (peripheral)	NINA-B3 (central)	1M	23	92 kbit/s (6, 6)
DUT (peripheral)	NINA-B3 (central)	1M	23	68 kbit/s (24, 40)
DUT (central)	NINA-B3 (peripheral)	1M	247	209 kbit/s (6, 6)
DUT (central)	NINA-B3 (peripheral)	1M	247	TBD (15, 15)
DUT (central)	NINA-B3 (peripheral)	1M	247	343 kbit/s (24, 40)
DUT (peripheral)	NINA-B3 (central)	1M	247	192 kbit/s (6, 6)
DUT (peripheral)	NINA-B3 (central)	1M	247	TBD (15, 15)
DUT (peripheral)	NINA-B3 (central)	1M	247	300 kbit/s (24, 40)
DUT (central)	NINA-B3 (peripheral)	2M	23	N/A
DUT (peripheral)	NINA-B3 (central)	2M	23	N/A
DUT (central)	NINA-B3 (peripheral)	2M	247	N/A
DUT (peripheral)	NINA-B3 (central)	2M	247	N/A

Optimal configuration: Enable LL PDU payload size (Data Length Extension) and ATT MTU size negotiation with default Connection Interval.

11.6 DUT – ODIN-W2, simplex

Device A	Device B	PHY	MTU	Result (including connection interval)
DUT (central)	ODIN-W2 (peripheral)	1M	23	112 kbit/s (6,6)
DUT (central)	ODIN-W2 (peripheral)	1M	23	28 kbit/s (24, 40)
DUT (peripheral)	ODIN-W2 (central)	1M	23	81 kbit/s (6,6)
DUT (peripheral)	ODIN-W2 (central)	1M	23	20 kbit/s (24, 40)

Optimal configuration: Use Connection Interval 6, 6.

11.7 DUT – ODIN-W2, duplex

Device A	Device B	PHY	MTU	Result (including connection interval)
DUT (central)	ODIN-W2 (peripheral)	1M	23	66 kbit/s (6, 6)
DUT (central)	ODIN-W2 (peripheral)	1M	23	20 kbit/s (24,40)
DUT (peripheral)	ODIN-W2 (central)	1M	23	52 kbit/s (6, 6)
DUT (peripheral)	ODIN-W2 (central)	1M	23	15 kbit/s (24,40)

Optimal configuration: Use Connection Interval 6, 6.

11.8 DUT – iOS device, simplex

Device A	Device B	PHY	MTU	Result (including connection interval)
iOS (central)	DUT (peripheral)	1M	23	TBD (6, 6)
iOS (central)	DUT (peripheral)	1M	182	144 kbit/s (6, 6)
iOS (central)	DUT (peripheral)	1M	247	TBD (24, 40)
DUT (peripheral)	iOS (central)	1M	23	TBD (6, 6)
DUT (peripheral)	iOS (central)	1M	182	133 kbit/s (6,6)
DUT (peripheral)	iOS (central)	1M	247	TBD (24, 40)
iOS (central)	DUT (peripheral)	2M	23	N/A
DUT (peripheral)	iOS (central)	2M	23	N/A
iOS (central)	DUT (peripheral)	2M	247	N/A
DUT (peripheral)	iOS (central)	2M	247	N/A

Optimal configuration: Enable LL PDU payload size (Data Length Extension) and ATT MTU size negotiation, with Connection Interval 6, 6.

11.9 DUT – iOS device, duplex

Device A	Device B	PHY	MTU	Result (including connection interval)
iOS (central)	DUT (peripheral)	1M	23	TBD (6, 6)
iOS (central)	DUT (peripheral)	1M	182	54 kbit/s (6, 6)
iOS (central)	DUT (peripheral)	1M	182	TBD (24, 40)
DUT (peripheral)	iOS (central)	1M	23	TBD (6,6)
DUT (peripheral)	iOS (central)	1M	182	104 kbit/s (6, 6)
DUT (peripheral)	iOS (central)	1M	182	TBD (24, 40)
iOS (central)	DUT (peripheral)	2M	23	N/A
DUT (peripheral)	iOS (central)	2M	23	N/A
iOS (central)	DUT (peripheral)	2M	247	N/A
DUT (peripheral)	iOS (central)	2M	247	N/A

Optimal configuration: Enable LL PDU payload size (Data Length Extension) and ATT MTU size negotiation, with Connection Interval 6, 6.

11.10 DUT – Android device, simplex

Device A	Device B	PHY	MTU	Result (including connection interval)
Android (central)	DUT (peripheral)	1M	23	TBD (6, 6) (High connection priority)
DUT (peripheral)	Android (central)	1M	23	TBD (6, 6) (High connection priority)
Android (central)	DUT (peripheral)	1M	247	315 kbit/s (6,6)
DUT (peripheral)	Android (central)	1M	247	650 kbit/s (6,6)

Device A	Device B	PHY	MTU	Result (including connection interval)
Android (central)	DUT (peripheral)	2M	23	N/A
DUT (peripheral)	Android (central)	2M	23	N/A
Android (central)	DUT (peripheral)	2M	247	N/A
DUT (peripheral)	Android (central)	2M	247	N/A

Optimal configuration: Enable LL PDU payload size (Data Length Extension) and ATT MTU size negotiation, with Connection Interval 6, 6.

11.11 DUT – Android device, duplex

Device A	Device B	PHY	MTU	Result (including connection interval)
Android (central)	DUT (peripheral)	1M	23	TBD (6, 6) (High connection priority)
DUT (peripheral)	Android (central)	1M	23	TBD (6, 6) (High connection priority)
Android (central)	DUT (peripheral)	1M	247	196 kbit/s (6, 6)
DUT (peripheral)	Android (central)	1M	247	407 kbit/s (6,6)
Android (central)	DUT (peripheral)	2M	23	N/A
DUT (peripheral)	Android (central)	2M	23	N/A
Android (central)	DUT (peripheral)	2M	247	N/A
DUT (peripheral)	Android (central)	2M	247	N/A

Optimal configuration: Enable LL PDU payload size (Data Length Extension) and ATT MTU size negotiation, with Connection Interval 6, 6.

Appendix

A Glossary

Abbreviation	Definition
ATT	Attribute Protocol
DUT	Device Under Test
LE	Low Energy
LL	Link Layer
MTU	Maximum Transmission Unit
N/A	Not Applicable
PDU	Protocol Data Unit
PHY	Physical Layer
SPS	Serial Port Service
SW	Software
TBD	To be determined
UART	Universal Asynchronous Receiver-Transmitter serial interface

Table 2: Explanation of the abbreviations and terms used

Related documents

[1] u-connectXpress AT commands manual, UBX-14044127
[2] u-connectXpress Low energy serial port service protocol specification, UBX-16011192
[3] s-center evaluation software - https://www.u-blox.com/en/product/s-center
[4] s-center user guide, UBX-16012261
[5] EVK-NINA-B1 Evaluation kit for NINA-B1 modules, user guide UBX-15028120
[6] u-blox Bluetooth low energy app, Android Version
[7] u-blox Bluetooth low energy app, iOS Version

☞ For product change notifications and regular updates of u-blox documentation, register on our website, www.u-blox.com.

Revision history

Revision	Date	Name	Comments
R01	30-Jun-2017	tvon, kgom	Initial release.
R02	24-Apr-2018	apet, kgom	Included support and throughput results for NINA-B1 software version 4.0.0. Added the AT commands for configuration.
R03	22-May-2019	mape, kgom	Added results for NINA-B3, NINA-B2 and ANNA-B112. Renamed this document.
R04	19-Sep-2019	mape	Updated chapter 1. Corrected the result for DUT (central) in section 5.2.
R05	31-Oct-2019	flun	Added throughput results for NINA-B2 v2.1.x, NINA-W15 v2.1.x
R06	17-Mar-2020	flun, mape, ctur	Updated the test setup recommendations and Included editorial revisions in all chapters.
R07	15-Jan-2021	mape	Added NINA-B3 SW 3.0, NINA-B1 SW 6.0. Renamed document.
R08	19-Jul-2021	mape	Corrections to chapter 7.5.

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