u-connectXpress

Bluetooth Low Energy Serial Port Service

Protocol specification

Abstract

This document describes the u-connectXpress Bluetooth® Low Energy Serial Port Service, which is a non-standard Bluetooth LE service developed by u-blox to support uses cases previously supported by Serial Port Profile on Bluetooth Classic. The u-connectXpress Bluetooth® Low Energy Serial Port Service specification is open and may be implemented in any Bluetooth Low Energy device to enable generic data transmission. The Serial Port Service is implemented on top of the Generic Attribute Profile (GATT).

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Document information

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This document applies to the following products:

Product series	Software version
ANNA-B1	All
ANNA-B41	All
NINA-B1	All
NINA-B2	All
NINA-B31	All
NINA-B41	All
NINA-W15	All
ODIN-W2	All

Contents

1 Overview

Bluetooth® Basic Rate/Enhanced Data Rate (BR/EDR) supports the Serial Port Profile (SPP) that emulates a serial port over air. As Bluetooth Low Energy (LE) does not support this profile there is no standardized way of transferring generic data over the air using this technology.

This specification describes the u-connectXpress Low Energy Serial Port Service, which is a non-standard Bluetooth LE service developed by u-blox to support uses cases previously supported by the Serial Port Profile in Bluetooth Classic.

The specification is open and may be implemented in any Bluetooth Low Energy device to enable generic data transmission to and from a u-blox modules running u-connectXpress software.

☞ If u-connectXpress software is running on both your central and peripheral device there is no need for you to go into the details of this specification since the Serial Port Service is implemented in the u-connectXpress software.

Serial Port Service is implemented on top of the Generic Attribute Profile (GATT). It contains the following characteristics:

- FIFO for reading and writing data
- Credits to simulate the Bluetooth BR/EDR credit-based flow control

To connect, the central/client side sets up the ACL (Asynchronous Connection-Less) link and enables indications for both the FIFO and credits characteristics. The server side sends the number of credits to the client using the credit indication, and the client writes the number of credits to the server. The credits correspond to the number of packets the remote side may write before receiving new credits. Received credits are added to the remaining ones (if any).

Once connected and credits have been received, data transmission may start. The client writes to the FIFO and the server sends indications or notifications with the FIFO data.

Connections without credits are also supported. Connections without credits are faster to establish and ideal for scenarios where a small amount of data shall be transferred.

☞ This mode does not support flow control and the receiver side has no mean to stop the data flow. This means the data may get lost if the receiver side cannot handle all the received data.

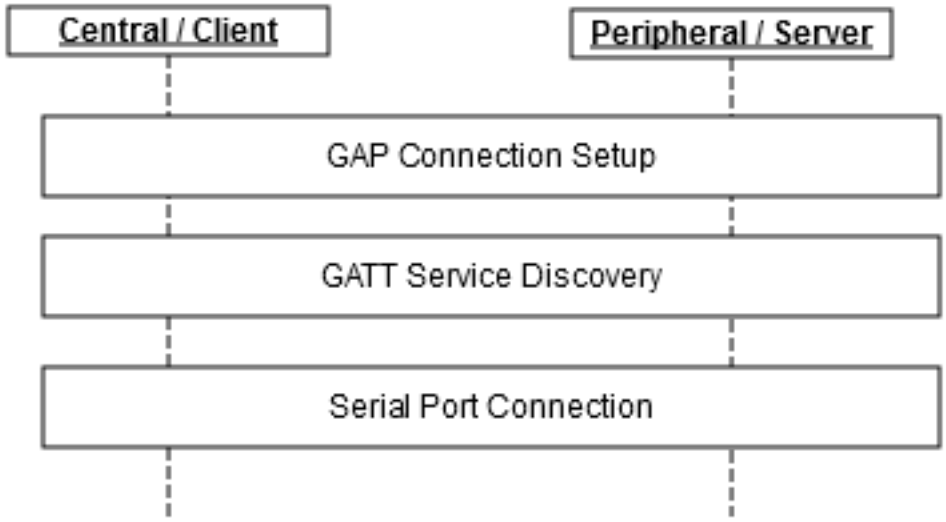

Figure 1: SPS connection setup

2 GAP connection setup

In most cases, the GAP connection is set up when the peripheral makes a standard advertisement and the central detects the advertisement and identifies the peripheral as the device it wants to connect to. Typically, the central is a smart phone making a scan, and when it finds the correct remote device, it sets up the connection.

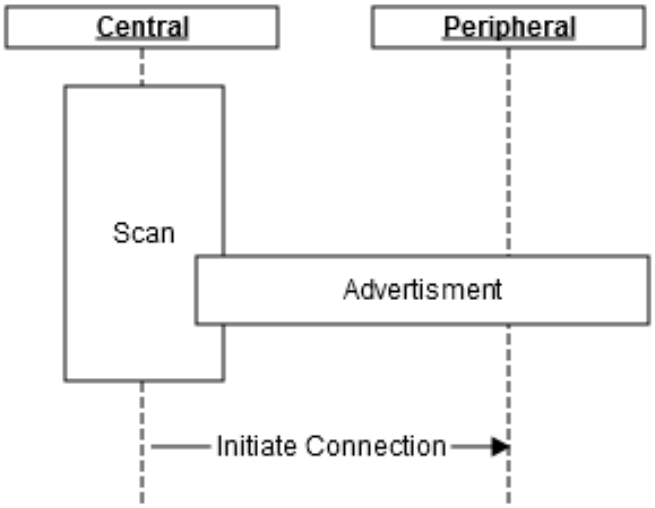

Figure 2: GAP connection setup

However, in some cases, it may be preferred that the peripheral knows to what central it wants to have a connection. In that case, the peripheral makes a directed advertisement and when the central detects the advertisement, directed to itself, it must set up the connection.

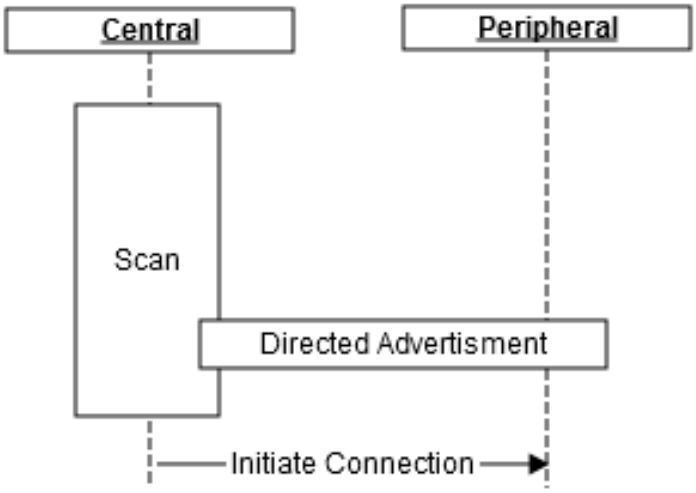

Figure 3: Directed GAP connection setup

If possible, it may be a good idea that the remaining connection setup is done with a short connection interval. There are a few packets that must be transmitted for a complete serial port connection setup and a shorter connection interval decreases the total connect time. Once complete, the connection interval can be changed to a more appropriate one.

3 GATT service discovery

Before a central makes a connection setup, it must find all relevant attribute handles. This can be done in several ways and there is no preferred way to do so as long as all the required handles are obtained. Caching is recommended to keep the total connection setup time as low as possible for future connections.

4 Serial port connection

The peripheral contains a Serial Port Service with FIFO and credits characteristics.

The FIFO characteristics are used for writing data from the central to the peripheral and to "notify/indicate" data from the peripheral to the central.

The credit characteristics simulate the Bluetooth BR/EDR credit-based flow control. It is allowed only to transmit the number of packets over air that matches the received number of credits. Received credits are added to the remaining ones. The receiving side must always keep available buffers that matches with the number of outgoing credits. The benefit of the credit-based flow control is that no data will be lost.

The credits characteristic is optional and an implementation may choose not to support it. This means Serial Port connection without the use of credits can be established. At connection establishment, the client may also choose not to use the credits even though it is supported by the server.

A connection that uses credits is hereafter referred to as a credit-based connection or connection with flow control.

A connection that does not use credits is hereafter referred to as a connection without credits or without flow control.

A connection without flow control is faster to set up and is ideal for transfers of smaller amount of data. Especially in scenarios, where cached attribute handles and client configuration state can be used, application data can be transferred immediately after the ACL link has been established without doing any service search or writing client configuration characteristics.

There is a well-defined serial port connection setup. It involves enabling notification and indications, and exchanging credits.

To avoid an undefined state, the transitions between credit-based connection and connection without credits cannot be swapped during an ongoing ACL connection.

4.1 Serial Port Service

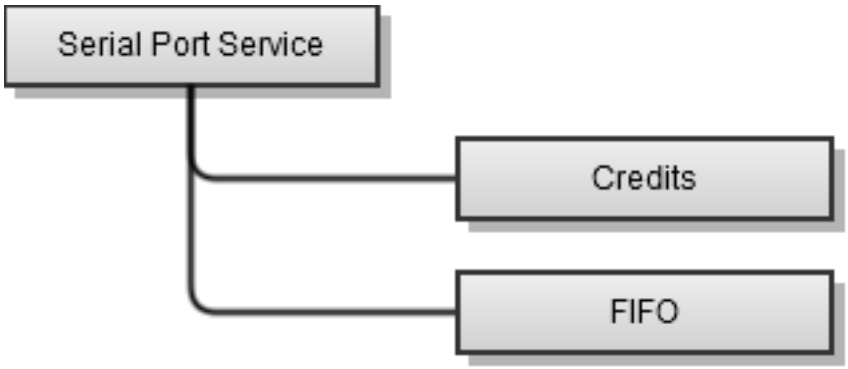

Figure 4: Characteristics of Serial Port Service

UUID: 0x2456e1b926e28f83e744f34f01e9d701

This Serial Port Service holds the following two characteristics:

- One serial support for sending and receiving data (FIFO) on, and
- Another for sending and receiving credits

4.1.1 Serial port FIFO characteristic

The FIFO characteristic contains two attributes – value and client configuration.

4.1.1.1 Value

UUID: 0x2456e1b926e28f83e744f34f01e9d703

Type: uint8 array (20 bytes = min MTU - opcode_size - handle_size)

Properties: Indication/notification/write/write no response

The FIFO characteristic represents the data to be sent to the external interface, for example, UART. All data that is received on this characteristic should be placed in an internal FIFO or directly put on the external interface.

When data is received on the external interface, the data should be put in the internal FIFO.

4.1.1.2 Client configuration

Properties: write

The client configuration must be enabled for either notifications or indications before receiving the data. The client configuration should be stored for bonded devices.

4.1.2 Serial port credits characteristic [Optional]

The credits characteristic contains two attributes – value and client configuration.

4.1.2.1 Value

UUID: 0x2456e1b926e28f83e744f34f01e9d704

Type: int8 (one byte)

Properties: Indication/notification/write/write no response

The credits characteristic is optional. The credits characteristic is used to send and receive credits. For a credit-based connection, credits must have been received before sending data on the FIFO. Both client (via writing) and server (via indication/notifications) must send it.

A connection with flow control is established by the central sending credits to the peripheral. The peripheral accepts the connection by sending credits to the central. It may reject the connection by responding with credits data with value -1 (0xFF) to the central. A connection with flow control is disconnected by writing credits data with value -1 (0xFF). The disconnect is not confirmed.

For a connection without flow control, the credits characteristic is not used.

4.1.2.2 Client configuration

Properties: write

The client configuration must be enabled for either notifications or indications before receiving the credits. The client configuration should be stored for bonded devices.

4.2 Bonding

For bonded devices, the state of the client configuration characteristic shall be stored. This means that the procedure to set up a connection is little different for bonded and non-bonded devices. If a device is bonded, then the client configuration characteristics do not have to be written before transferring credits or data.

4.3 Sequence diagrams

4.3.1 Connection with flow control [Non-bonded]

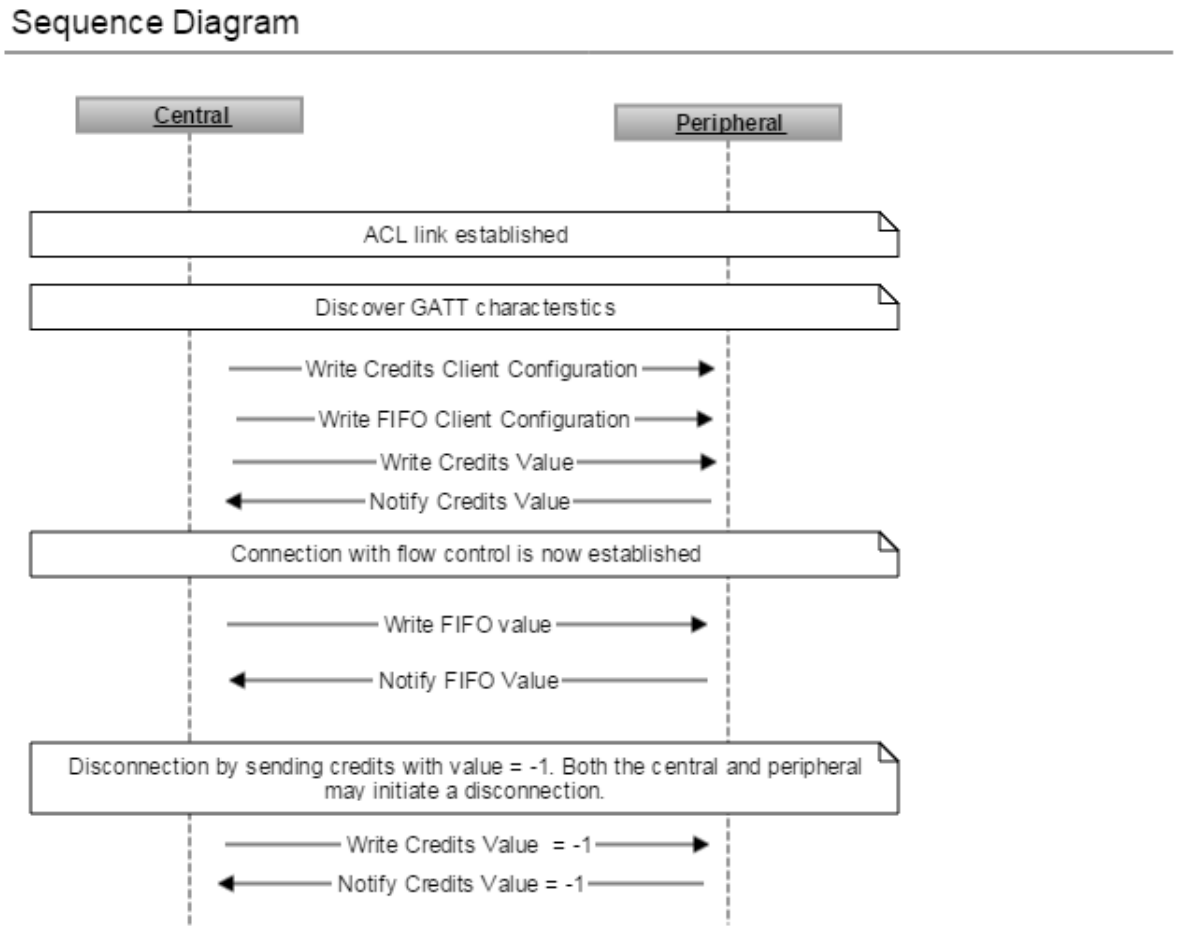

Figure 5: Connection with flow control (non-bonded)

☞ The “notify credits value” should not be sent before setting or enabling FIFO client configuration.

4.3.2 Connection with flow control [Bonded]

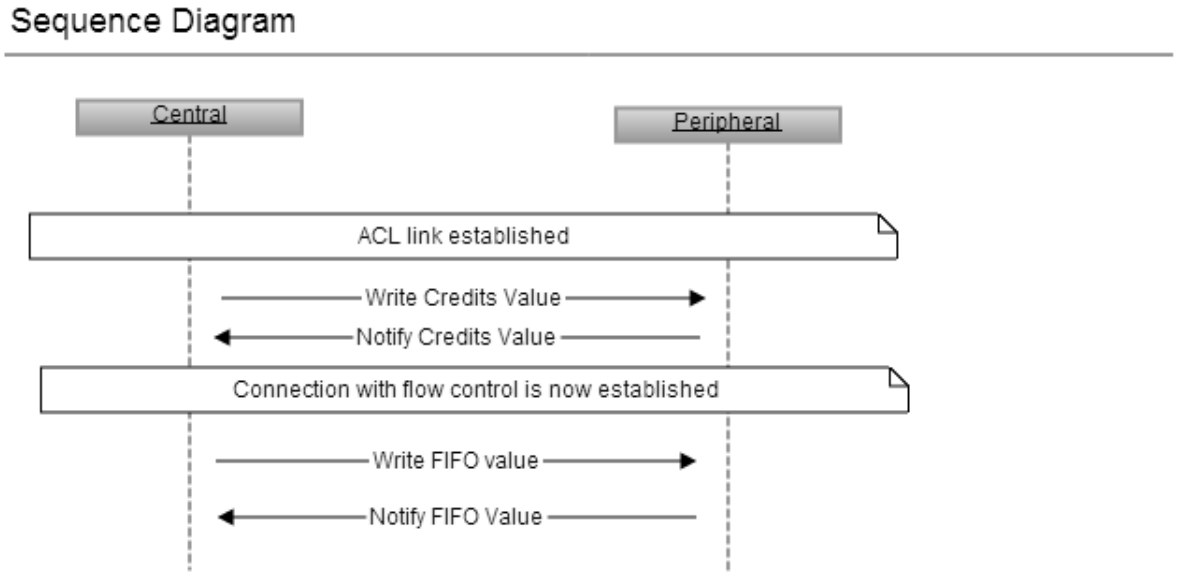

Figure 6: Connection with flow control (bonded)

4.3.3 Connection without flow control [Non-bonded]

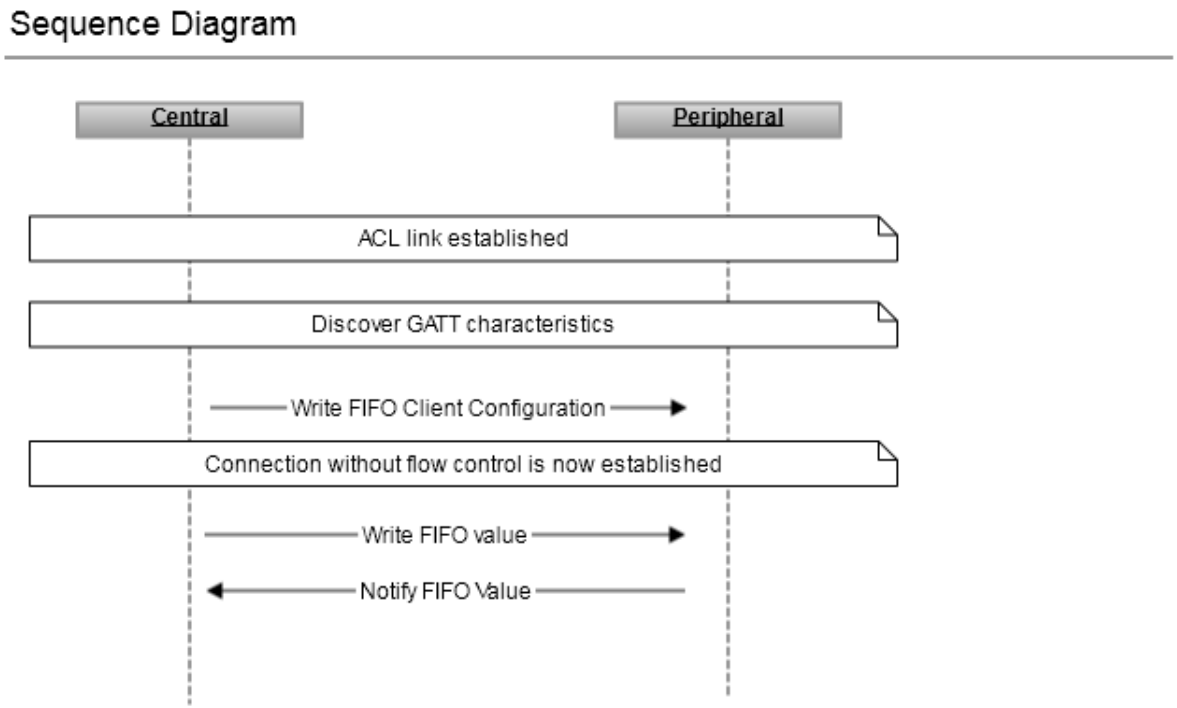

Figure 7: Connection without flow control (non-bonded)

4.3.4 Connection without flow control [Bonded]

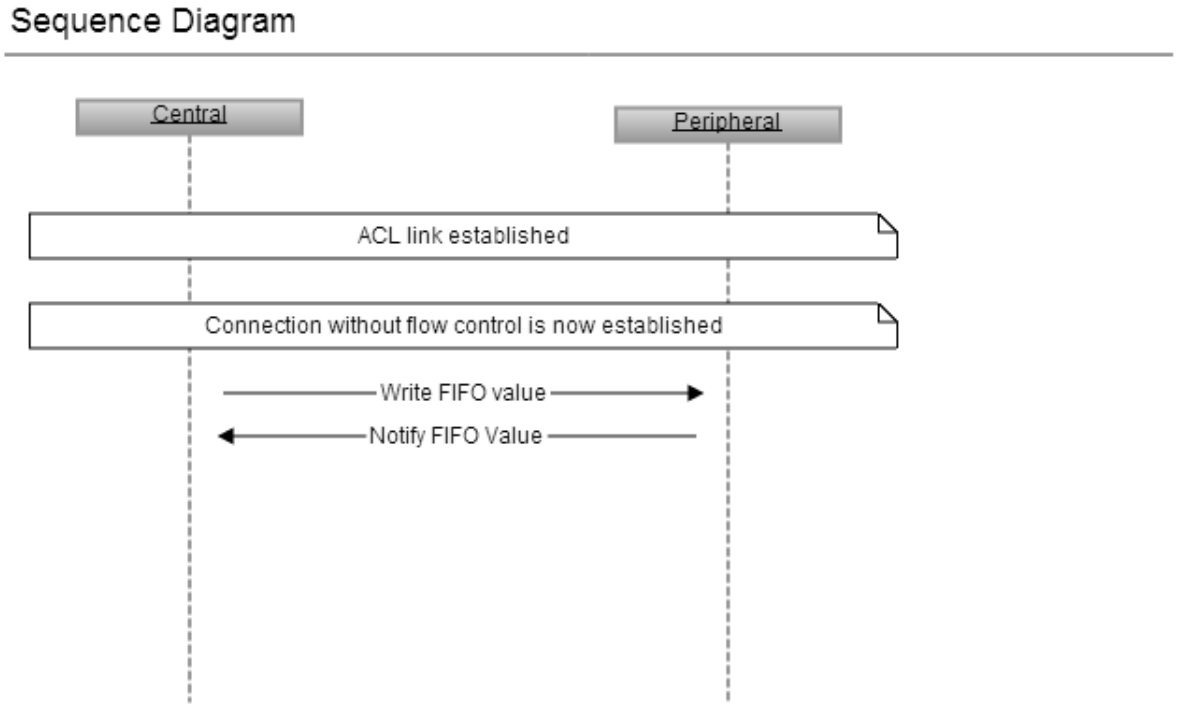

Figure 8: Connection without flow control (bonded)

Since the state of the credits client configuration is stored on the peripheral and central, both the devices are aware of when the credit-based flow control is being used.

When no credits are used, the entire ACL link must be teared down to disconnect the SPS link.

To avoid an undefined state, the transitions between credit-based connection and connection without credits cannot be swapped during an ongoing ACL connection.

5 Requirements

M = Mandatory

O = Optional

C1 = Either notification, indications or both shall be supported

5.1 Central

Feature	Support
FIFO characteristic write	M
FIFO characteristic write no response	M
Credits characteristic write	M
Credits characteristic write no response	M

5.2 Peripheral

Feature	Support
FIFO characteristic indication	C1
FIFO characteristic notification	C1
Credits characteristic indication	C1
Credits characteristic notification	C1

Revision history

Revision	Date	Name	Comments
R01	7-Jul-2016	pber	Initial release.
R02	19-Jan-2017	mtho, mlju, kgom	Minor change in section 4. On page 2, replaced Document status with Disclosure restriction and included type numbers for the new software versions of NINA-B1 and ODIN-W2.
R03	30-Mar-2017	kgom	On page 2, replaced type numbers and firmware version with All to denote support for all type numbers and firmware versions of NINA-B1 and ODIN-W2.
R04	16-May-2017	kgom	Minor updates.
R05	3-Jul-2017	kgom	Replaced firmware with software.
R06	28-Nov-2017	hwin	Minor changes in section 4 and 4.3.4.
R07	27-Mar-2018	kgom	Included support for ANNA-B112.
R08	17-Apr-2018	kgom	Included support for NINA-B2.
R09	12-Sep-2018	kgom	Included support for NINA-B31.
R10	13-Feb-2019	kgom	Included support for NINA-B316.
R11	28-Jun-2019	kgom	Included support for NINA-W15.
R12	04-Feb-2021	flun, mhan	Included support for NINA-W156, NINA-B41 and ODIN-W263. Renamed document and simplified applicable products table on page 2. Minor change in section 1.
R13	18-Feb-2021	mhan	Removed NINA-W13 from applicable products table on page 2.
R14	29-Nov-2021	hisa	Included support for ANNA-B412

Contact

For complete contact information, visit us at www.u-blox.com.

u-blox Offices

North, Central and South America

u-blox America, Inc.

Phone: +1 703 483 3180
E-mail: info_us@u-blox.com

Regional Office West Coast:

Phone: +1 408 573 3640
E-mail: info_us@u-blox.com

Technical Support:

Phone: +1 703 483 3185
E-mail: support_us@u-blox.com

Headquarters
Europe, Middle East, Africa

u-blox AG

Phone: +41 44 722 74 44
E-mail: info@u-blox.com
Support: support@u-blox.com

Asia, Australia, Pacific

u-blox Singapore Pte. Ltd.

Phone: +65 6734 3811
E-mail: info_ap@u-blox.com
Support: support_ap@u-blox.com

Regional Office Australia:

Phone: +61 3 9566 7255
E-mail: info_anz@u-blox.com
Support: support_ap@u-blox.com

Regional Office China (Beijing):

Phone: +86 10 68 133 545
E-mail: info_cn@u-blox.com
Support: support_cn@u-blox.com

Regional Office China (Chongqing):

Phone: +86 23 6815 1588
E-mail: info_cn@u-blox.com
Support: support_cn@u-blox.com

Regional Office China (Shanghai):

Phone: +86 21 6090 4832
E-mail: info_cn@u-blox.com
Support: support_cn@u-blox.com

Regional Office China (Shenzhen):

Phone: +86 755 8627 1083
E-mail: info_cn@u-blox.com
Support: support_cn@u-blox.com

Regional Office India:

Phone: +91 80 405 092 00
E-mail: info_in@u-blox.com
Support: support_in@u-blox.com

Regional Office Japan (Osaka):

Phone: +81 6 6941 3660
E-mail: info_jp@u-blox.com
Support: support_jp@u-blox.com

Regional Office Japan (Tokyo):

Phone: +81 3 5775 3850
E-mail: info_jp@u-blox.com
Support: support_jp@u-blox.com

Regional Office Korea:

Phone: +82 2 542 0861
E-mail: info_kr@u-blox.com
Support: support_kr@u-blox.com

Regional Office Taiwan:

Phone: +886 2 2657 1090
E-mail: info_tw@u-blox.com
Support: support_tw@u-blox.com