



ANR014 PROTEUS QUICKSTART

CONNECT A SMART PHONE TO A PROTEUS
BLUETOOTH LOW ENERGY RADIO MODULE

VERSION 1.0

JULY 15, 2019

Revision history

Manual version	Notes	Date
1.0	<ul style="list-style-type: none">Initial version	July 2019

Abbreviations and abstract

Abbreviation	Name	Description
BTMAC		Bluetooth conform MAC address of the module used on the RF-interface.
CS	Checksum	Byte wise XOR combination of the preceding fields.
BLE	Bluetooth Low Energy	According to Bluetooth specification.
BT	Bluetooth	According to Bluetooth specification.
Central		Bluetooth Low Energy device role that scans for advertising packets & initiates connections, e.g. smart phone.
DTM	Direct test mode	Mode to test Bluetooth specific RF settings.
GAP	Generic Access Profile	The GAP provides a basic level of functionality that all Bluetooth devices must implement.
I/O	Input/output	Pinout description.
LPM	Low power mode	Mode for efficient power consumption.
MAC		MAC address of the module.
MTU	Maximum transmission unit	Maximum packet size of the Bluetooth connection.
Payload		The intended message in a frame / package.
Peripheral		Bluetooth Low Energy device role that provides services & advertises, e.g. sensor or our Proteus module.
RF	Radio frequency	Describes wireless transmission.
RSSI	Receive Signal Strength Indicator	The RSSI indicates the strength of the RF signal. Its value is always printed in two's complement notation.
SoC		System on Chip.
Soft device		Operating system used by the nRF52 chip.
UART	Universal Asynchronous Receiver Transmitter	Allows the serial communication with the module.
[HEX] 0xhh	Hexadecimal	All numbers beginning with 0x are hexadecimal numbers. All other numbers are decimal, unless stated otherwise.

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1 Introduction

The Proteus series is a radio module series that is based on Nordic Semiconductors SoC which presents various Bluetooth Low Energy (BLE) and low power features.

By default, a radio module of the Proteus series can be controlled and configured by the host using predefined commands, in the so called command mode.

This application note describes how to setup a connection between a BLE enabled smart device, e.g. smart phone or tablet, to a Proteus module and how to interchange data in command mode. These steps are described with help of the nRF Connect App which is an open source App providing standard BLE functions for iOS as well as for Android devices.



There is a second operation mode, that offers a transparent UART interface to transmit data without any overhead on the UART. For more information concerning this mode, please refer to the application note **ANR004_Proteus-I_Peripheral_Only_Mode**.

2 Prerequisites

To follow the description in this application note, the following prerequisites may be helpful:

- A BLE enabled smart phone and the Nordic Semiconductor **nRF Connect** App
- A USB cable
- A Proteus evaluation board in factory state, for example
 - the Proteus-I evaluation board with only jumpers JP2, JP4 and JP6 set. Other jumpers not set.
 - the Proteus-II evaluation board with only jumpers JP2, JP4 and JP6 set. Other jumpers not set.

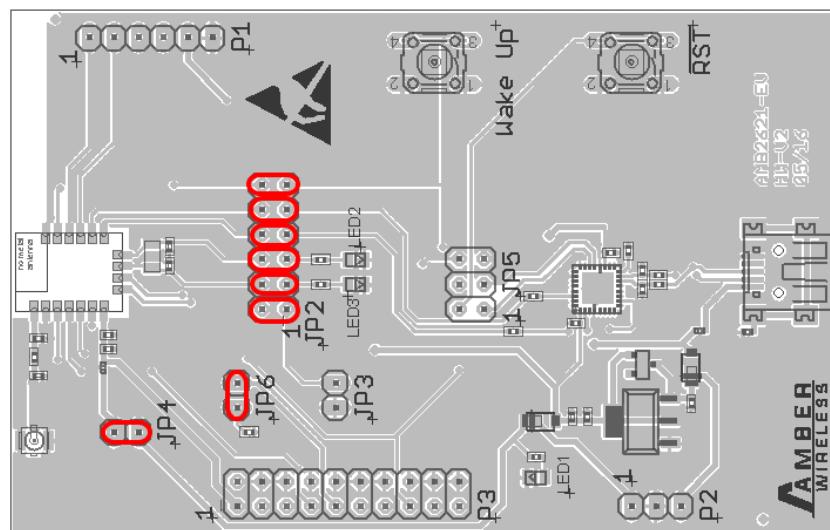


Figure 1: Default jumper placement of the Proteus-I and Proteus-II evaluation board. Red means "jumper must be set".



Figure 2: USB cable and evaluation board of the Proteus-I and Proteus-II radio module

The complete description of Proteus modules can be found in the respective radio module manual and application notes. This may be helpful to understand the background of the following quick start:

- Proteus-I
 - Proteus-I reference manual
 - Proteus-I advanced user guide **ANR002_Proteus-I_Advanced_Developer_Guide**
- Proteus-II
 - Proteus-II reference manual
 - Proteus-II advanced user guide **ANR005_Proteus-II_Advanced_Developer_Guide**

3 Quick start

The following description demonstrates how to setup a connection with a smart phone to a Proteus radio module.

3.1 Basics

The setup of a BLE connection to a Proteus module contains several steps:

1. Physical connection establishment

First of all, a physical connection has to be established. Therefore, a central device (usually smart phone) has to connect to the Proteus module which runs as peripheral.

2. Optional: Pairing process

Second, the pairing process is run that consists of the authentication and exchange of encryption information. The central device must request at least the same security level to access the characteristics of the Proteus module.

- In factory state, the Proteus module has no security enabled and this step can be neglected.
- Security can be enabled by modifying the user setting `RF_SecFlags`.



If the security level of the central device is lower than the security mode of the peripheral, the central cannot access the peripheral's characteristics. In this case, the central sends the notification enable message, which is ignored by the peripheral. Thus, the central signalizes an open connection, although it does not have access to the peripheral and thus data cannot be transmitted!

3. Optional: Exchange of the maximum transmission unit (MTU)

Next, the maximum transmission unit can be increased to allow the transmission of larger data packets. The Proteus module allows an MTU of up to 247 bytes, which results in a payload of up to 243 bytes. This step is optional. Not selecting a higher MTU will use the BT4.0 default MTU which results in 19 bytes payload for the user but will be compatible to pre BT 4.2 devices.

4. Discover the characteristics of the Proteus module SPP-like profile

Afterwards, the characteristics offered by the Proteus module have to be discovered by the central. This is needed to share the information how data can be transmitted.

5. Notification enable

To finalize the connection setup, the notification enabled message has to be send. With this feature, the peripheral device lets the central know, when there is new data, which is important for bidirectional data transmission. After this step, the channel is open and data transmission can start.

For the description, we assume that a smart phone is the initiator of the connection. Thus, it acts as central and the Proteus module acts as peripheral in figure 3.

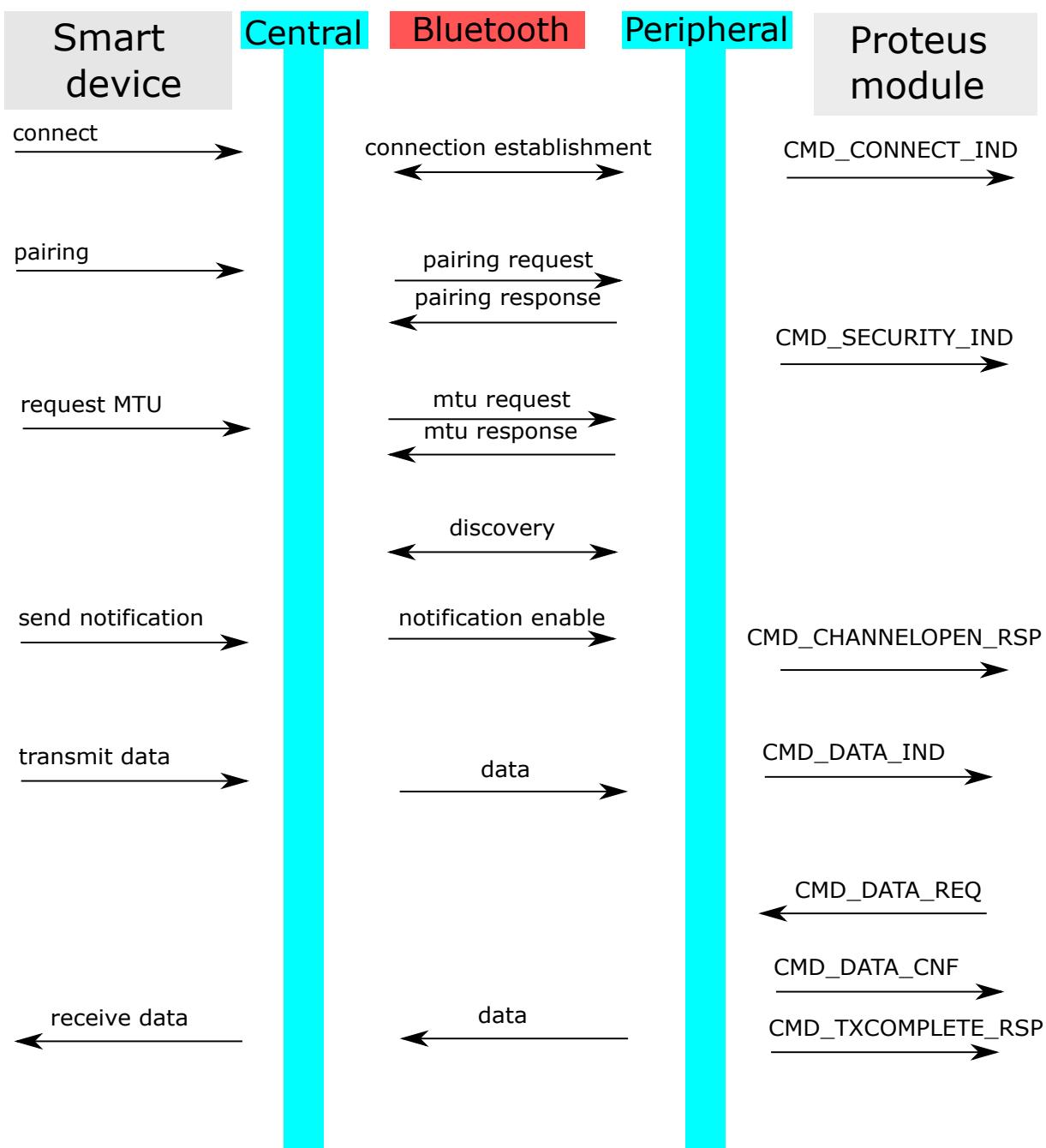
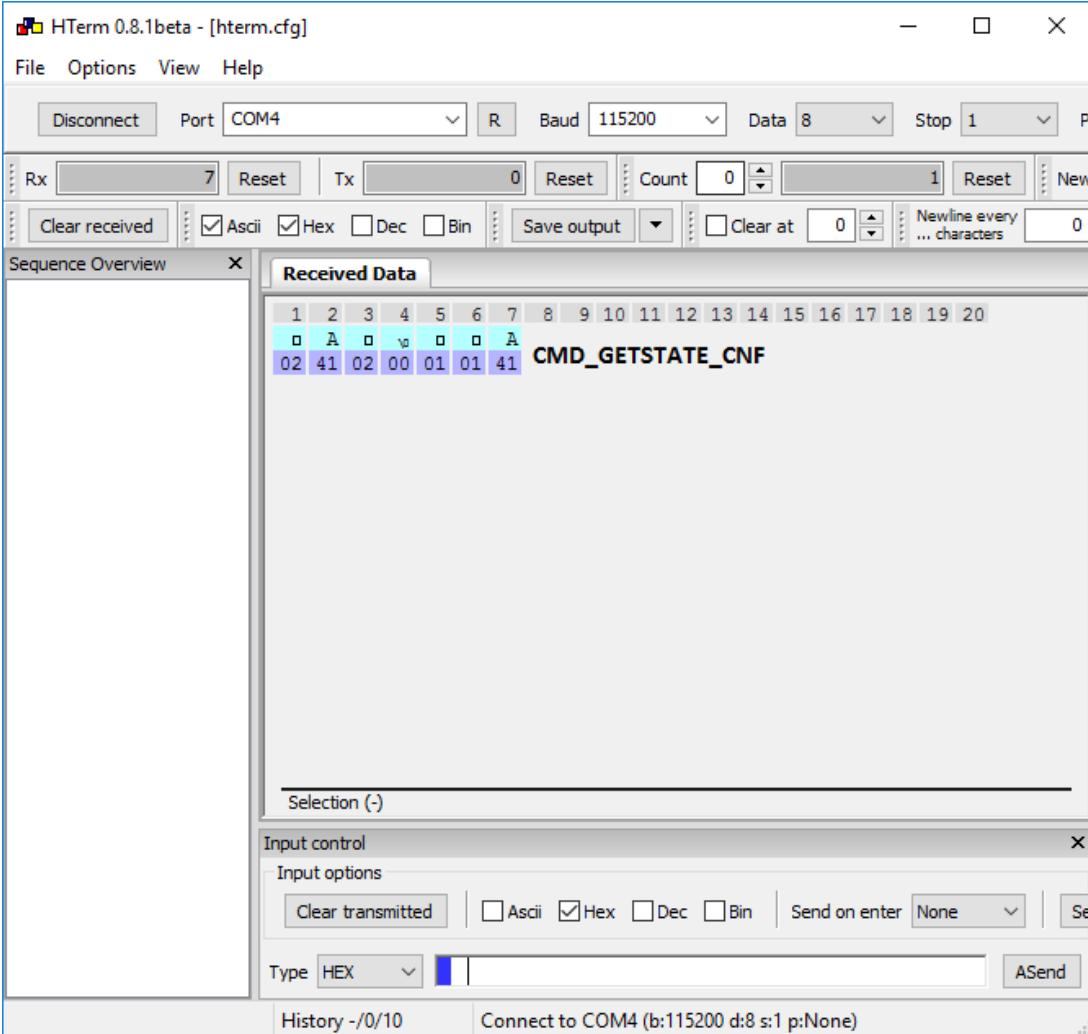


Figure 3: Steps for the connection setup

3.2 Connection setup example using the nRF Connect App

This chapter describes how to setup a connection to the Proteus module in command mode, when a smart phone and the **nRF Connect App** are used. Please perform the following steps:

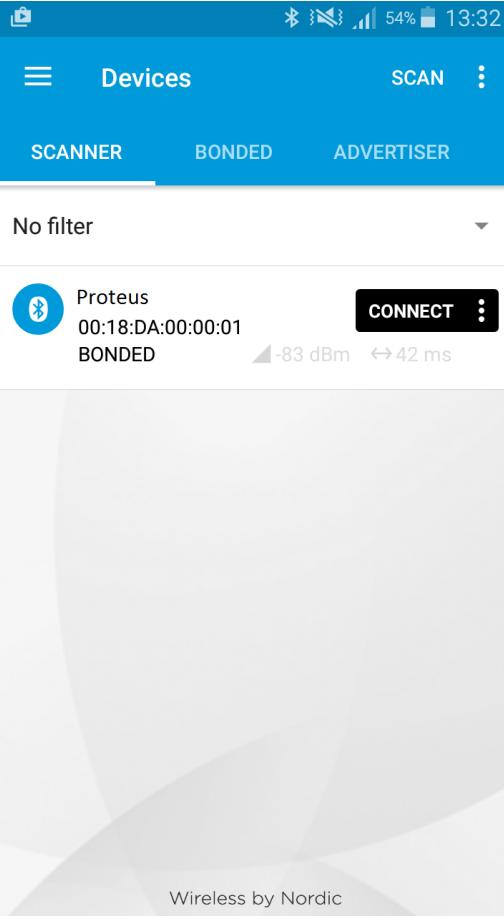
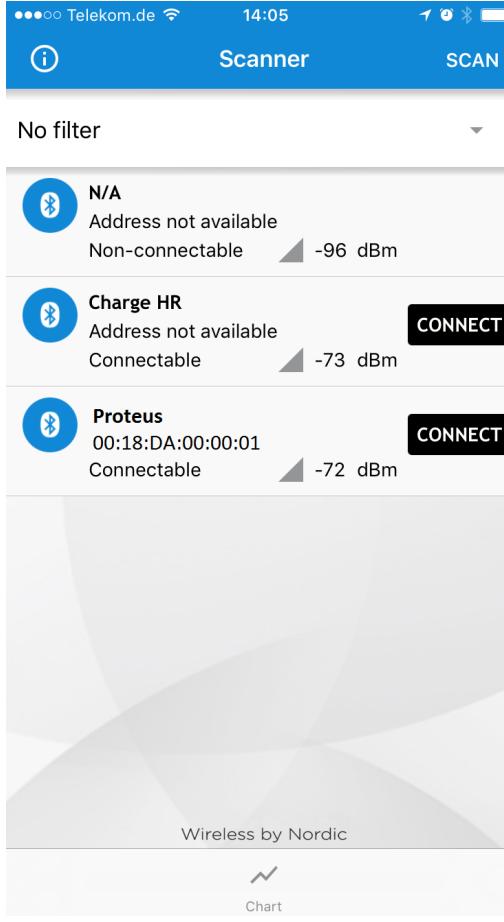
Android	iOS
<ul style="list-style-type: none"> • Connect the Proteus evaluation board to a PC using an USB cable. • Open a terminal program using the Proteus default UART settings (115200 Baud, 8n1). In this example we use the terminal program <i>hterm</i>, a free tool that can be downloaded www.der-hammer.info . • Press the reset button on the Proteus evaluation board. The Proteus module outputs a CMD_GETSTATE_CNF (0x02410200010141) to indicate that it is ready for operation. 	



The screenshot shows the HTerm 0.8.1beta terminal window. The title bar reads "HTerm 0.8.1beta - [hterm.cfg]". The menu bar includes File, Options, View, and Help. The control panel at the top has buttons for Disconnect, Port (set to COM4), R, Baud (set to 115200), Data (set to 8), Stop (set to 1), and P. Below the control panel are buttons for Rx (value 7), Reset, Tx (value 0), Reset, Count (value 0), and a series of buttons for Newline every ... characters (value 0). The "Sequence Overview" window on the left is empty. The main window is titled "Received Data" and shows a table of received bytes. The table has columns labeled 1 through 20. The data is as follows:

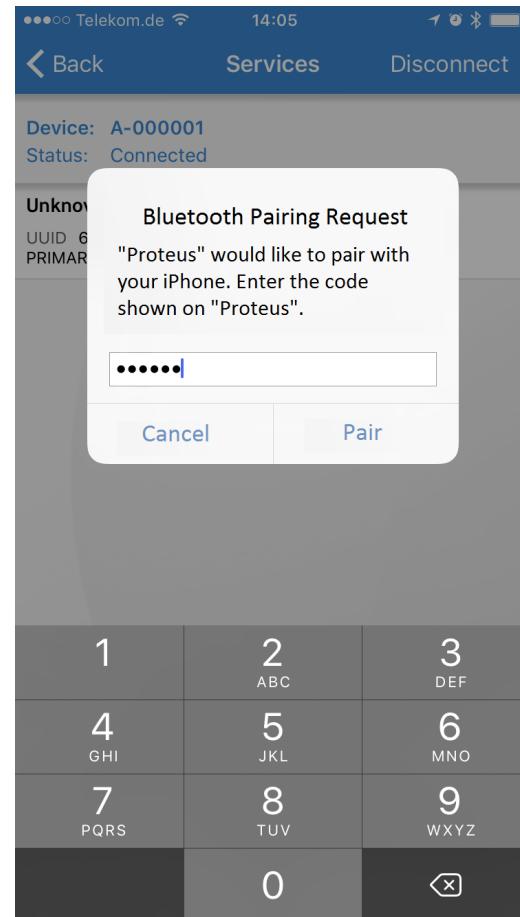
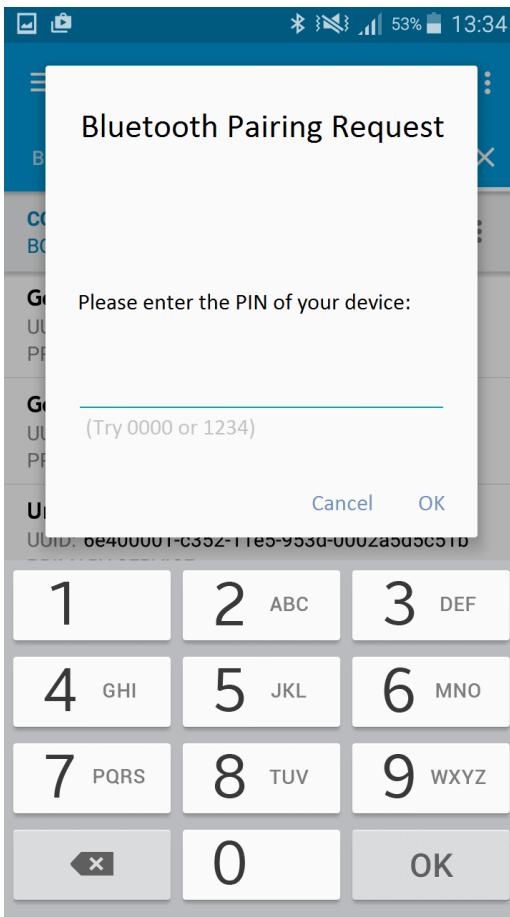
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
0	2	41	02	00	01	01	41	CMD_GETSTATE_CNF											

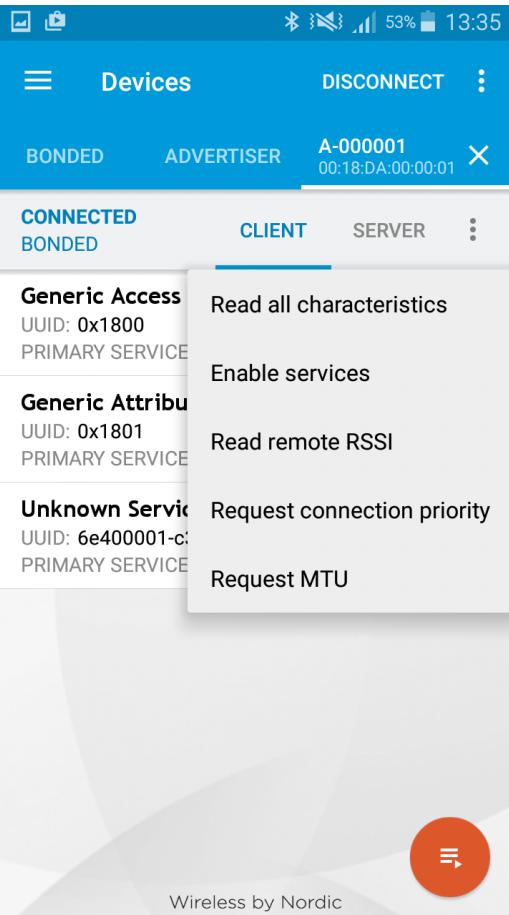
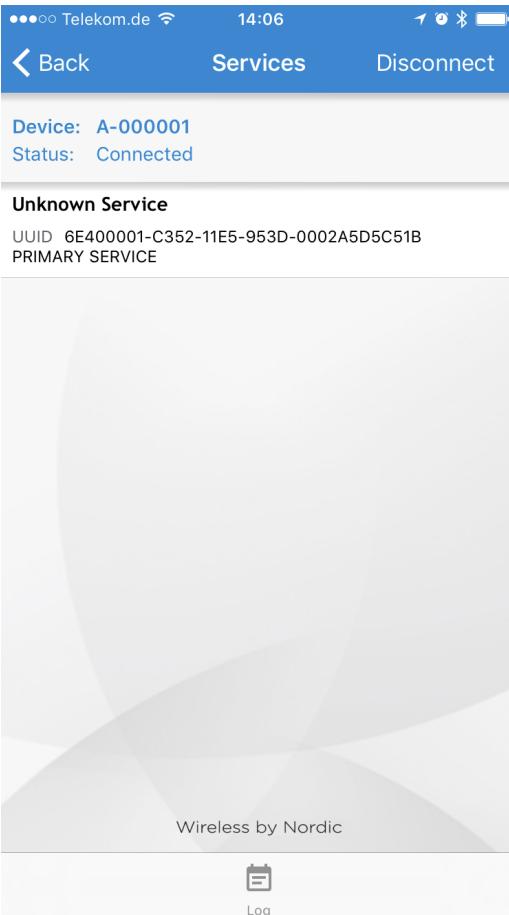
Below the table, the "Selection (-)" window is empty. The "Input control" window shows "Input options" with checkboxes for Ascii (unchecked), Hex (checked), Dec (unchecked), and Bin (unchecked). It also has a "Send on enter" dropdown set to "None" and an "ASend" button. The "Type" dropdown is set to "HEX". The bottom of the window has a "History -/0/10" button and a "Connect to COM4 (b:115200 d:8 s:1 p:None)" button.

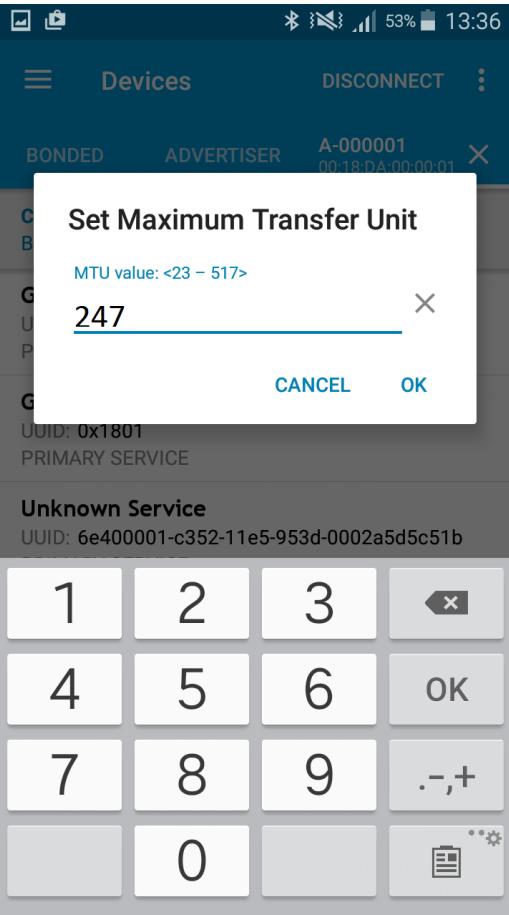
Android	iOS
<ul style="list-style-type: none"> Initially, the module is advertising. Thus, one LED of the Proteus evaluation board is blinking. Start your smart phone, enable the BLE feature and start the nRF Connect App. Press "SCAN" to find the module on the radio. In case several Proteus modules are found, the Bluetooth MAC 0x0018DAxxxx can be used to detect the right one. The Bluetooth MAC consists of the module's serial number, that can be also found on the module label. 	

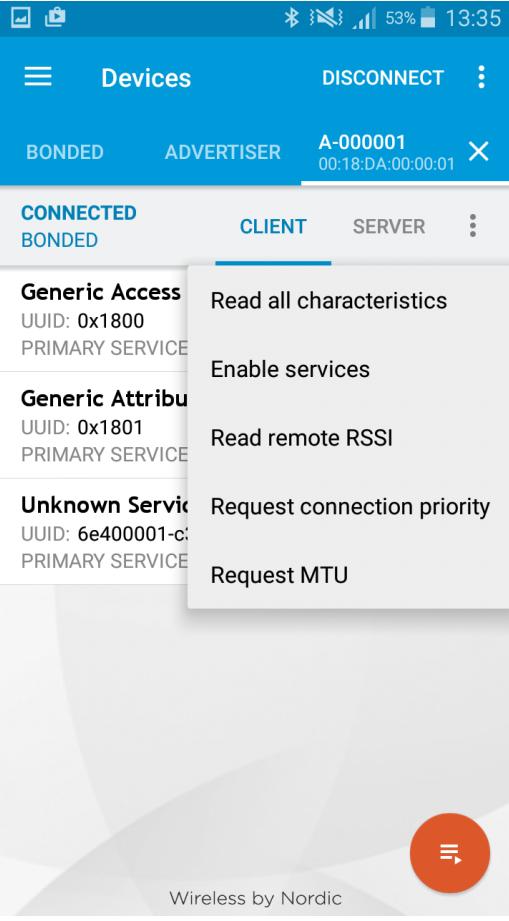
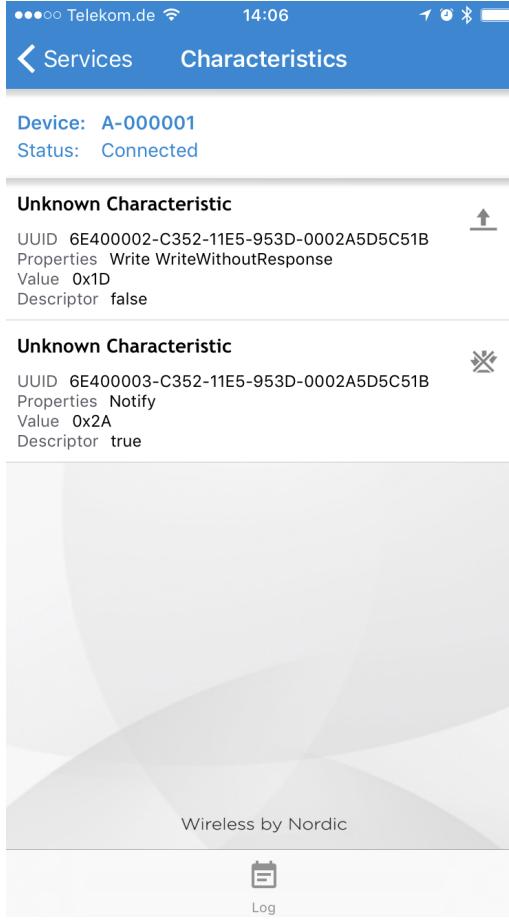
- When the module appears, press "CONNECT".

Android	iOS
<ul style="list-style-type: none"> As soon as the module has received the connection request from the smart phone the blinking LED will switch to constant on. Optional pairing: In case security has been configured before, the smart phone requests the user for pairing actions. In case of the static passkey authentication, the Proteus requests to enter the static passkey. The default passkey is "123123". The BT coupling requirement pop-up is shown on your smart phone. When the bonding feature is enabled in the authentication settings and the bonding information already exists, a re-entering of the passkey is not required when reconnecting. 	

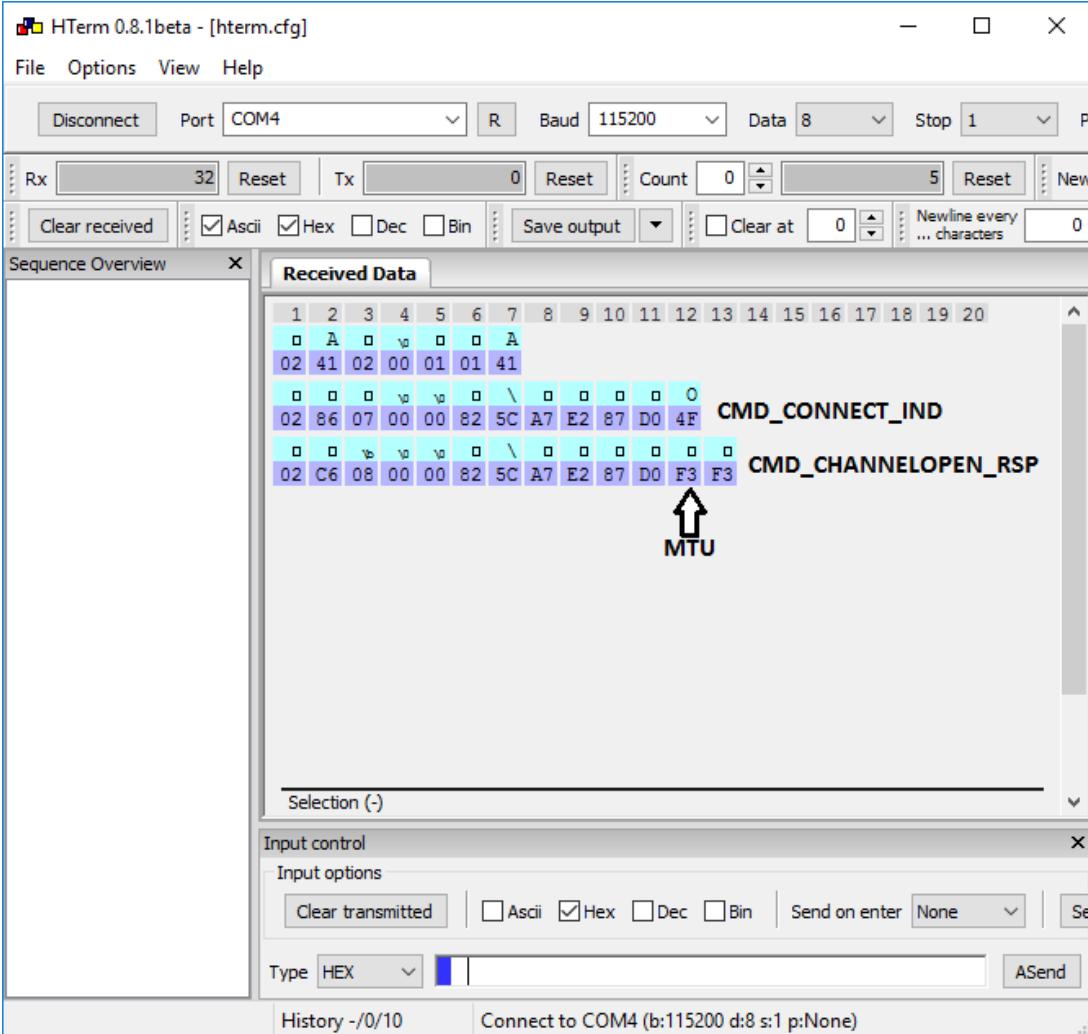


Android	iOS
<ul style="list-style-type: none"> Please click on the menu bullets on the right and press "Request MTU" to request for a larger MTU. 	<ul style="list-style-type: none"> Please click on the "Unknown Service" to start the service discovery and the MTU request. 

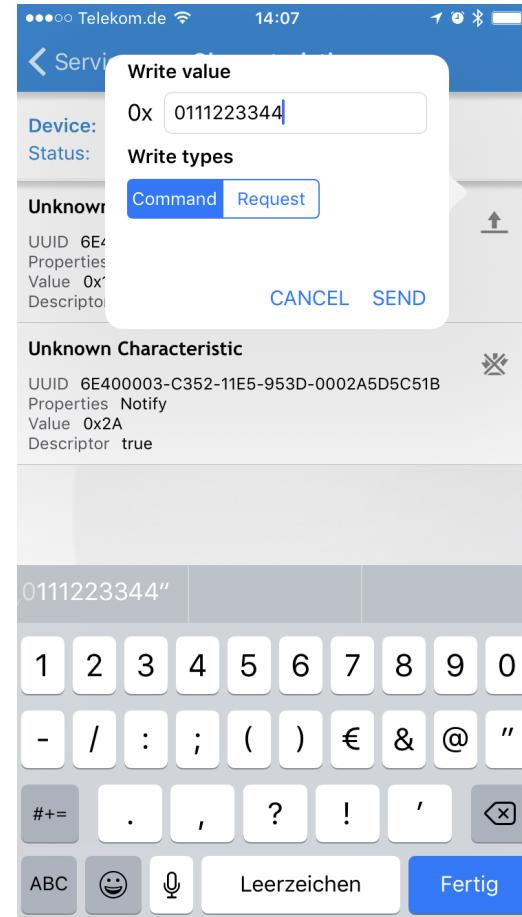
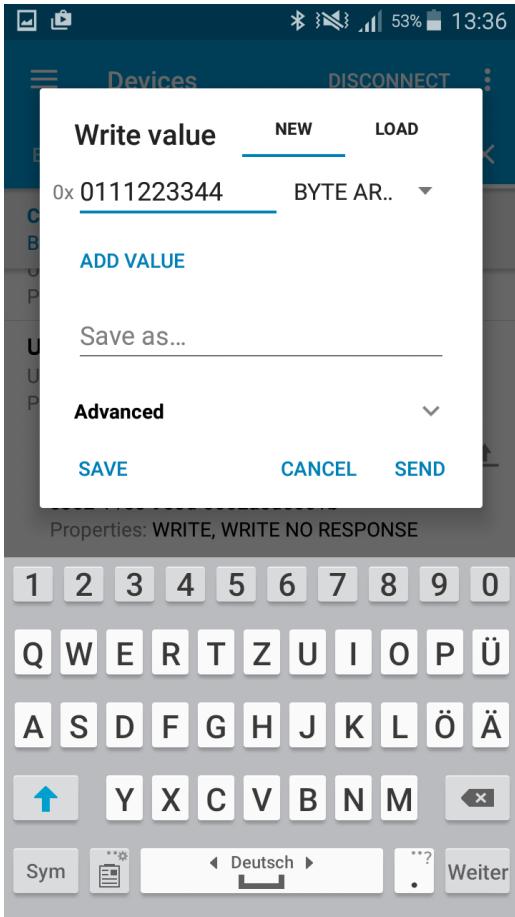
Android	iOS
<ul style="list-style-type: none">The Proteus module allows a MTU of up to 247 bytes, which results in a payload size of 243 bytes. 	<ul style="list-style-type: none">The iOS App runs this step simultaneously in the background, a user-defined MTU is not possible.

Android	iOS
<ul style="list-style-type: none"> Again click on the menu bullets on the right and press "Enable services" to enable the notifications. 	<ul style="list-style-type: none"> Press the arrow on the RX-characteristic 6E400003-C352-11E5-953D-0002A5D5C51B to enable the notifications. Press it until a cross appears (see below, it has to be pressed at least once). If a cross is already shown press it twice so the cross disappears and then reappears. 

- As soon as the module has received the notification enable request the second LED on the Proteus evaluation board is turned on. Now you are fully connected and you can access the characteristics to transmit and receive data.

Android	iOS
<p>• On the Proteus side, the radio module sent the corresponding CMD_CONNECT_IND (0x02860700...) and CMD_CHANNELOPEN_RSP (0x02C60800...) in between. These messages indicate that a connection has been setup and a link has been opened. The CMD_CHANNELOPEN_RSP message contains the MTU (maximum transmission unit) of the current link, which defines the maximum supported packet payload to be send. In this example it's 0xF3 (243_{dec}) bytes payload per packet.</p> 	

Android	iOS
<ul style="list-style-type: none"> To send data to the Proteus module, press the arrow next to the TX-characteristic 6E400002-C352-11E5-953D-0002A5D5C51B in the nRF Connect App. First enter 01 right behind the 0x as header byte, followed by your payload (for example 0x11 0x22 0x33 0x44) and press "SEND" to start the transmission. The maximum allowed payload size is dependent on the MTU that was selected in the connection process (see <code>CMD_CHANNELOPEN_RSP</code> message on the previous page). 	



Android			iOS			
Start signal	Command	Length	BTMAC	RSSI	Payload	CS
0x02	0x84	2 Bytes	6 Bytes	1 Byte	(Length - 7) Bytes	1 Byte
0x02	0x84	0x0B 0x00	0x82 0x5C 0xA7 0xE2 0x87 0xD0	0XCB	0x11 0x22 0x33 0x44	0xCE

HTerm 0.8.1beta - [hterm.cfg]

File Options View Help

Disconnect Port COM4 R Baud 115200 Data 8 Stop 1 P

Rx 162 Reset Tx 0 Reset Count 0 21 Reset New

Clear received Ascii Hex Dec Bin Save output Clear at Newline every characters

Sequence Overview x Received Data

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

02 41 02 00 01 01 41

02 86 07 00 00 82 5C A7 E2 87 D0 4F

02 C6 08 00 00 82 5C A7 E2 87 D0 F3 F3

02 84 0B 00 82 5C A7 E2 87 D0 CB 11 22 33 44 CE

CMD_DATA_IND

BTMAC of smart device **Payload**

Selection (-)

Input control

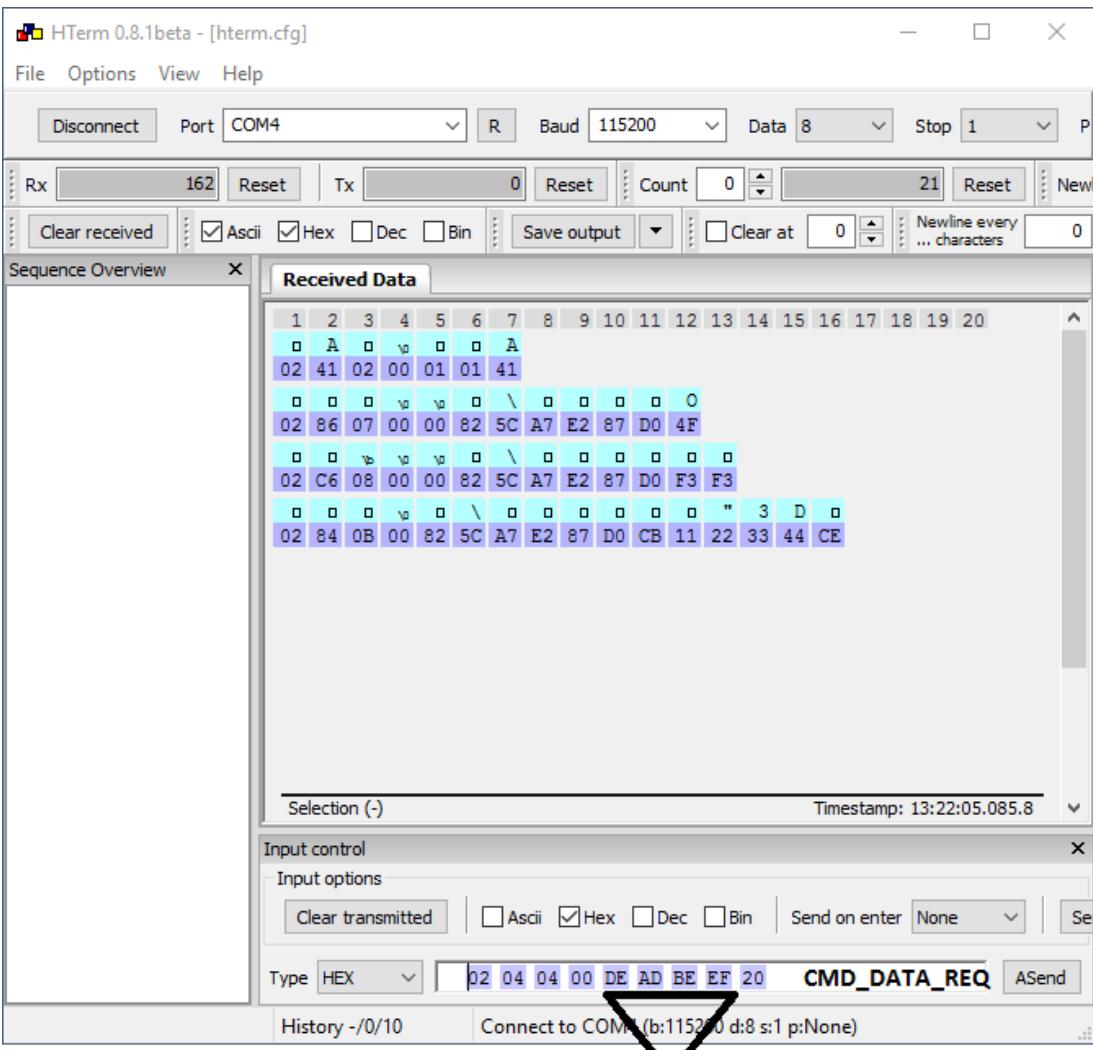
Input options

Clear transmitted Ascii Hex Dec Bin Send on enter None

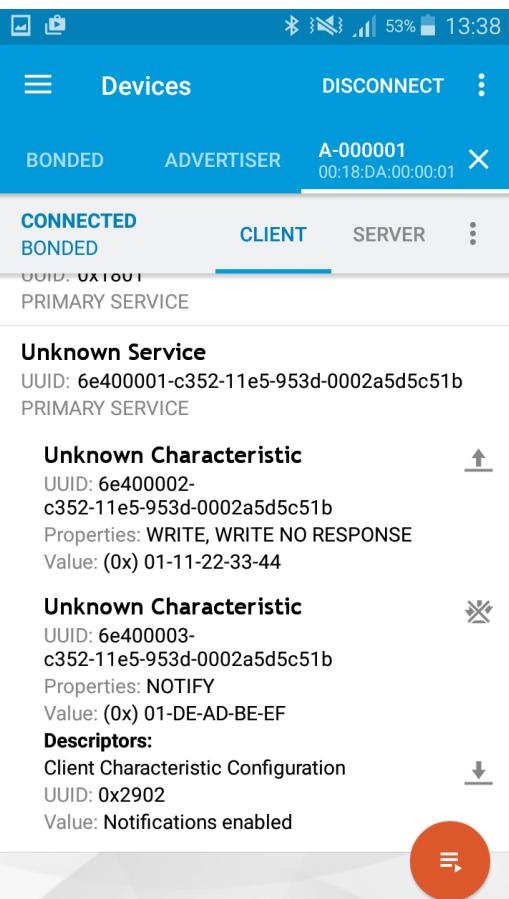
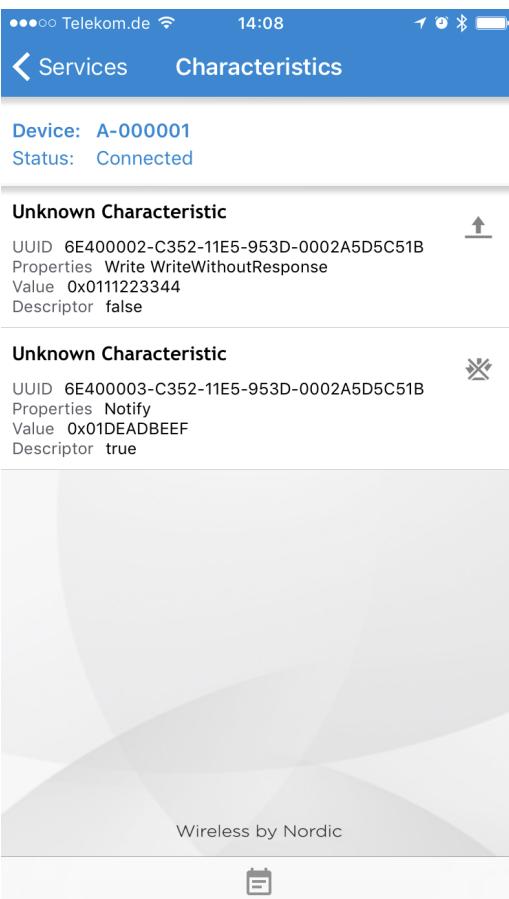
Type HEX ASend

History -/0/10 Connect to COM4 (b:115200 d:8 s:1 p:None)

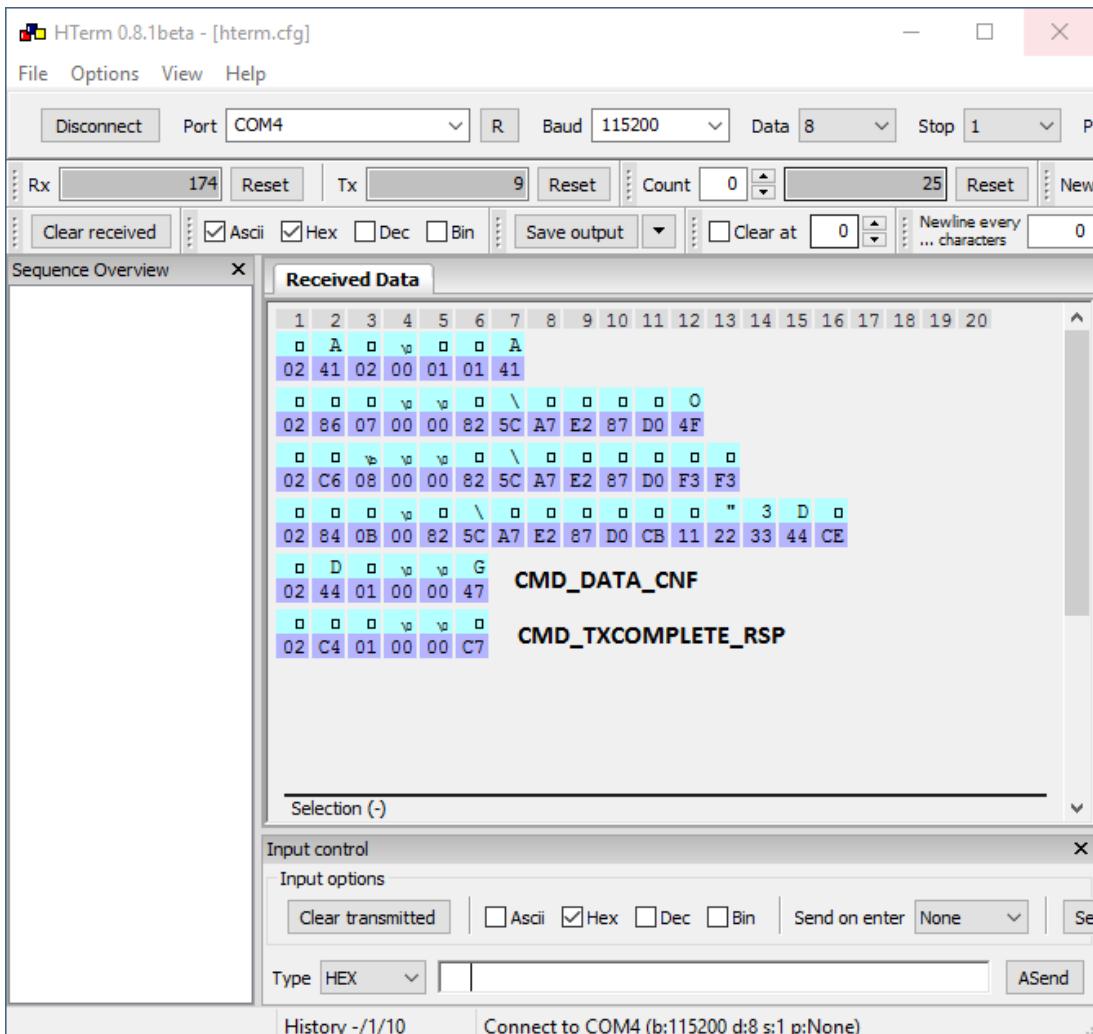
Android	iOS															
<ul style="list-style-type: none"> To send back data to the smart device simply insert your payload (here we choose 0xDE 0xAD 0xBE 0xEF) in a CMD_DATA_REQ message. The format of the CMD_DATA_REQ message is as follows, where the check sum (CS) is calculated as XOR of the preceding bytes: <table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th style="width: 20%;">Start signal</th> <th style="width: 20%;">Command</th> <th style="width: 20%;">Length</th> <th style="width: 20%;">Payload</th> <th style="width: 20%;">CS</th> </tr> </thead> <tbody> <tr> <td>0x02</td> <td>0x04</td> <td>2 Bytes</td> <td>Length Bytes</td> <td>1 Byte</td> </tr> <tr> <td>0x02</td> <td>0x04</td> <td>0x04 0x00</td> <td>0xDE 0xAD 0xBE 0xEF</td> <td>0x20</td> </tr> </tbody> </table> <ul style="list-style-type: none"> The header 0x01 of the radio frame header will be automatically applied by the module and is not part of the payload of the CMD_DATA_REQ message. 		Start signal	Command	Length	Payload	CS	0x02	0x04	2 Bytes	Length Bytes	1 Byte	0x02	0x04	0x04 0x00	0xDE 0xAD 0xBE 0xEF	0x20
Start signal	Command	Length	Payload	CS												
0x02	0x04	2 Bytes	Length Bytes	1 Byte												
0x02	0x04	0x04 0x00	0xDE 0xAD 0xBE 0xEF	0x20												



Payload, no header
0x01 needed

Android	iOS
<ul style="list-style-type: none"> The received data can be found in the RX-characteristic 6E400003-C352-11E5-953D-0002A5D5C51B. It contains the header byte 0x01 and the payload 0xDE 0xAD 0xBE 0xEF. 	
	

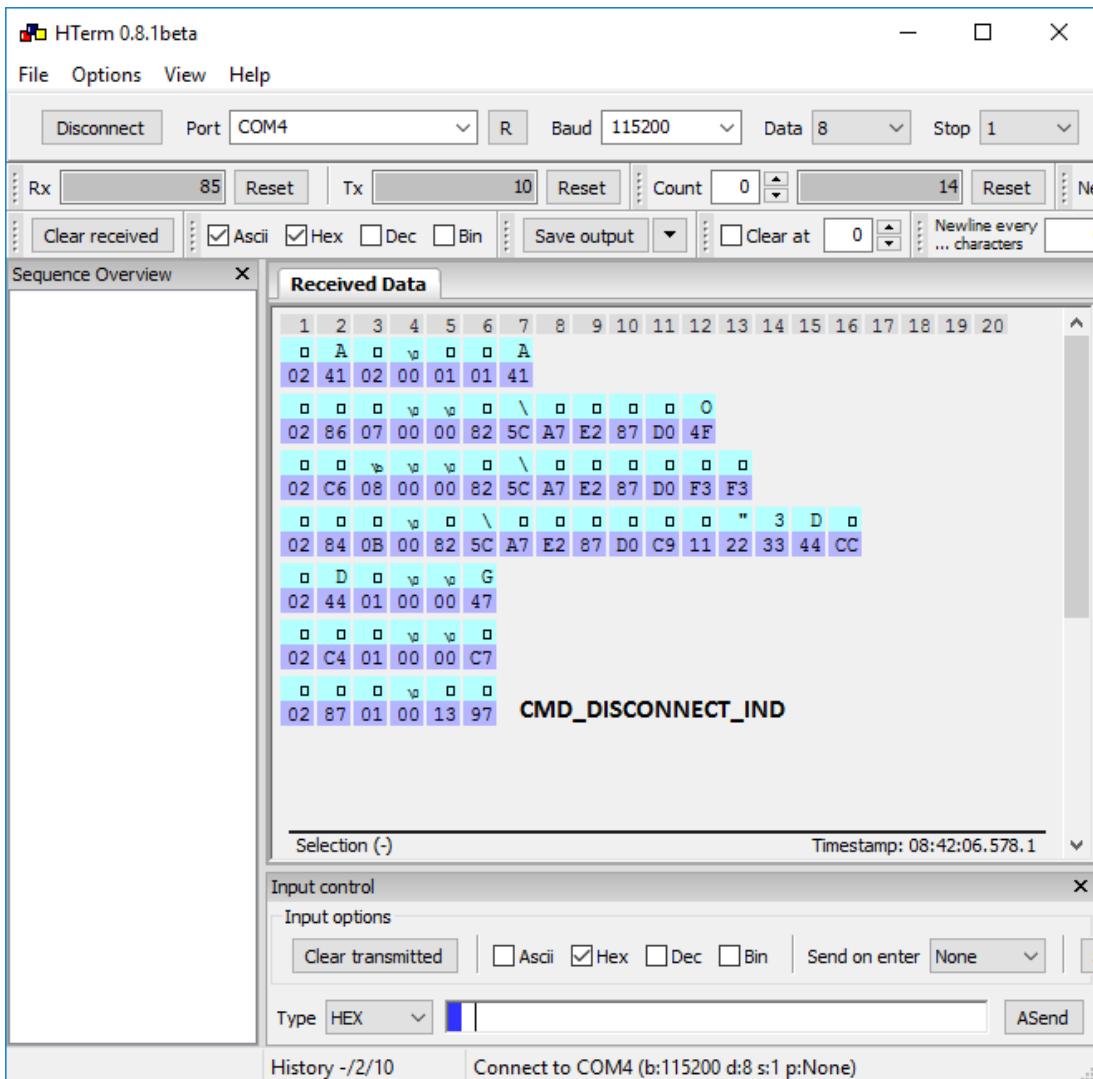
Android	iOS
<ul style="list-style-type: none"> When sending the CMD_DATA_REQ to the Proteus module, it responds with two different messages. First a CMD_DATA_CNF (0x024401000047) message is returned, as soon as the request was interpreted. Then a CMD_TXCOMPLETE_RSP (0x02C4010000C7) message is returned as soon as the data has been transmitted. 	



Android

iOS

- To disconnect the smart phone from the Proteus module, press the "DISCONNECT" button in the **nRF Connect** App. The Proteus module will output a **CMD_DISCONNECT_IND** (0x028701001397) message to indicate that the connection has been closed.



- After disconnecting the Proteus module starts advertising again, such that a reconnection can be performed.

3.3 Summary

In this application note, we demonstrated how to setup a connection between a smart phone and a Proteus Bluetooth Low Energy module. Furthermore, it has been shown how to transmit data from smart phone to a Proteus radio module and vice versa.

When developing a custom app, the same steps for connection setup have to be implemented. The **nRF Connect** App from Nordic Semiconductor can be taken as base for any custom app development, as its source code is freely available on the GitHub account of Nordic Semiconductor (*nRF Connect Android* and *nRF Connect iOS*).

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Any product-specific data sheets, manuals, application notes, PCN's, warnings and cautions must be strictly observed in the most recent versions and matching to the products firmware revisions. This documents can be downloaded from the product specific sections on the wireless connectivity homepage.

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6.9 Miscellaneous

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**Internet
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**Monitoring
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**Automated Meter
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