WÜRTH ELEKTRONIK

ANR014 Proteus Quickstart

Connect a smart phone to a Proteus Bluetooth LE radio module

Version 1.2

March 11, 2021

Revision history

Manual version	Notes	Date
1.0	• Initial version	July 2019
1.1	• Added description for Proteus-III • Updated address of Division Wireless Connectivity & Sensors location	January 2020
1.2	• Added example for connection setup using the Proteus Connect App • Added information on Proteus-III-SPI and the mini evaluation board	March 2021

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.
Central		Bluetooth® LE 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.
SPI	Serial Peripheral Interface	Allows the serial communication with the module.
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.

Contents

1 Introduction

The Proteus series is a radio module series that is based on Nordic Semiconductors SoC which presents various Bluetooth® LE 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 Bluetooth® LE 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 Bluetooth® LE 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 node **AN-R004_Proteus_Peripheral_Only_Mode**.

2 Prerequisites

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

- A Bluetooth® LE enabled smart phone including a suitable App, for example
  - the **Proteus Connect** App for Android [3][5] or iOS [4][6]
  - the Nordic Semiconductor **nRF Connect** App for Android [1] or iOS [2]
- A Proteus evaluation board in factory state, for example
  - the Proteus-I evaluation board with jumpers set as specified in figure 1. Other jumpers not set.
  - the Proteus-II evaluation board with jumpers set as specified in figure 1. Other jumpers not set.
  - the Proteus-III evaluation board with jumpers set as specified in figure 2. Other jumpers not set.
  - the Proteus-III-SPI mini evaluation board with jumpers set as specified in figure 3. Other jumpers not set.

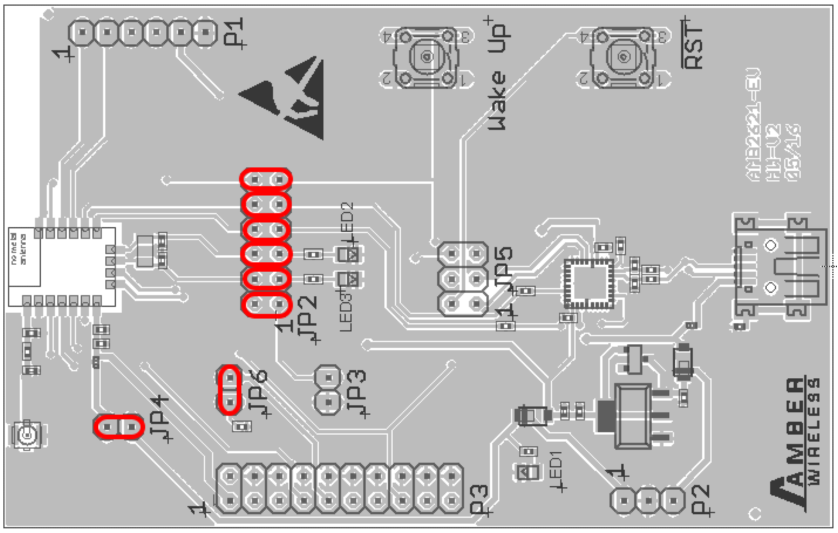


Figure 1: Default jumper placement of the Proteus-I and Proteus-II evaluation board. Red means "jumper must be set".

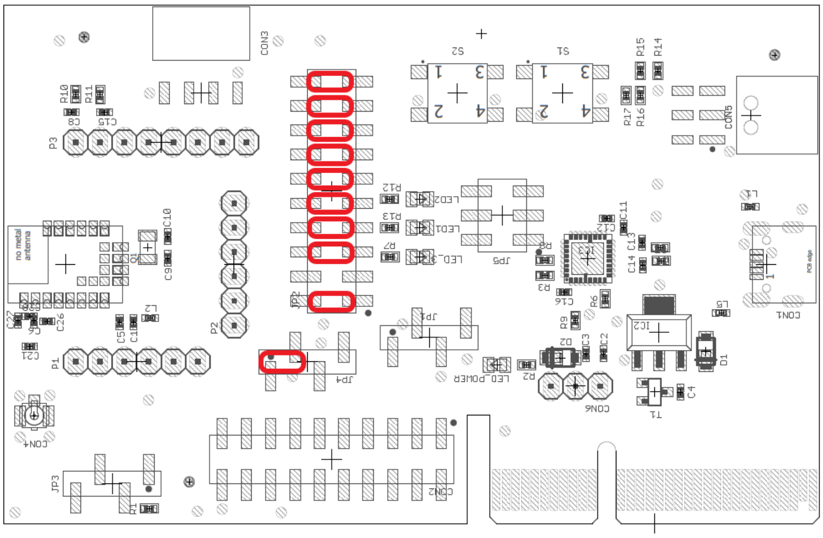


Figure 2: Default jumper placement of the Proteus-III evaluation board. Red means "jumper must be set".

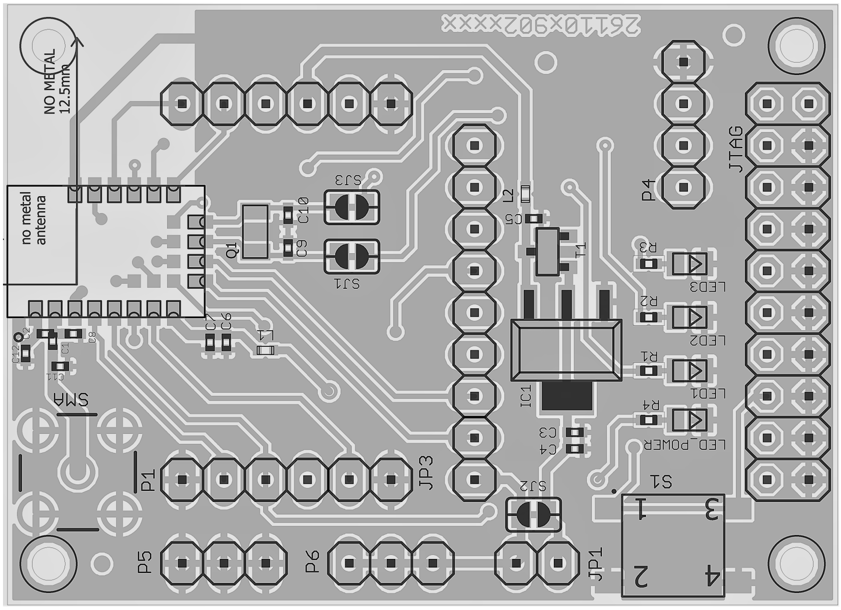


Figure 3: Default jumper placement of the Proteus-III-SPI mini evaluation board.

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**
- Proteus-III

  - Proteus-III reference manual
  - Proteus-III advanced user guide **ANR009_Proteus-III_Advanced_Developer_Guide**

- Proteus-III-SPI
  - Proteus-III-SPI reference manual
  - Proteus-III advanced user guide **ANR009_Proteus-III_Advanced_Developer_Guide**

3 Basics

The setup of a Bluetooth® LE connection to a Proteus radio 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 peripheral (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! In some cases, the peripheral may also disconnect to avoid to be blocked by attackers.

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 Bluetooth® 4.0 default MTU which results in 19 bytes payload for the user but will be compatible to pre Bluetooth® 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 4.

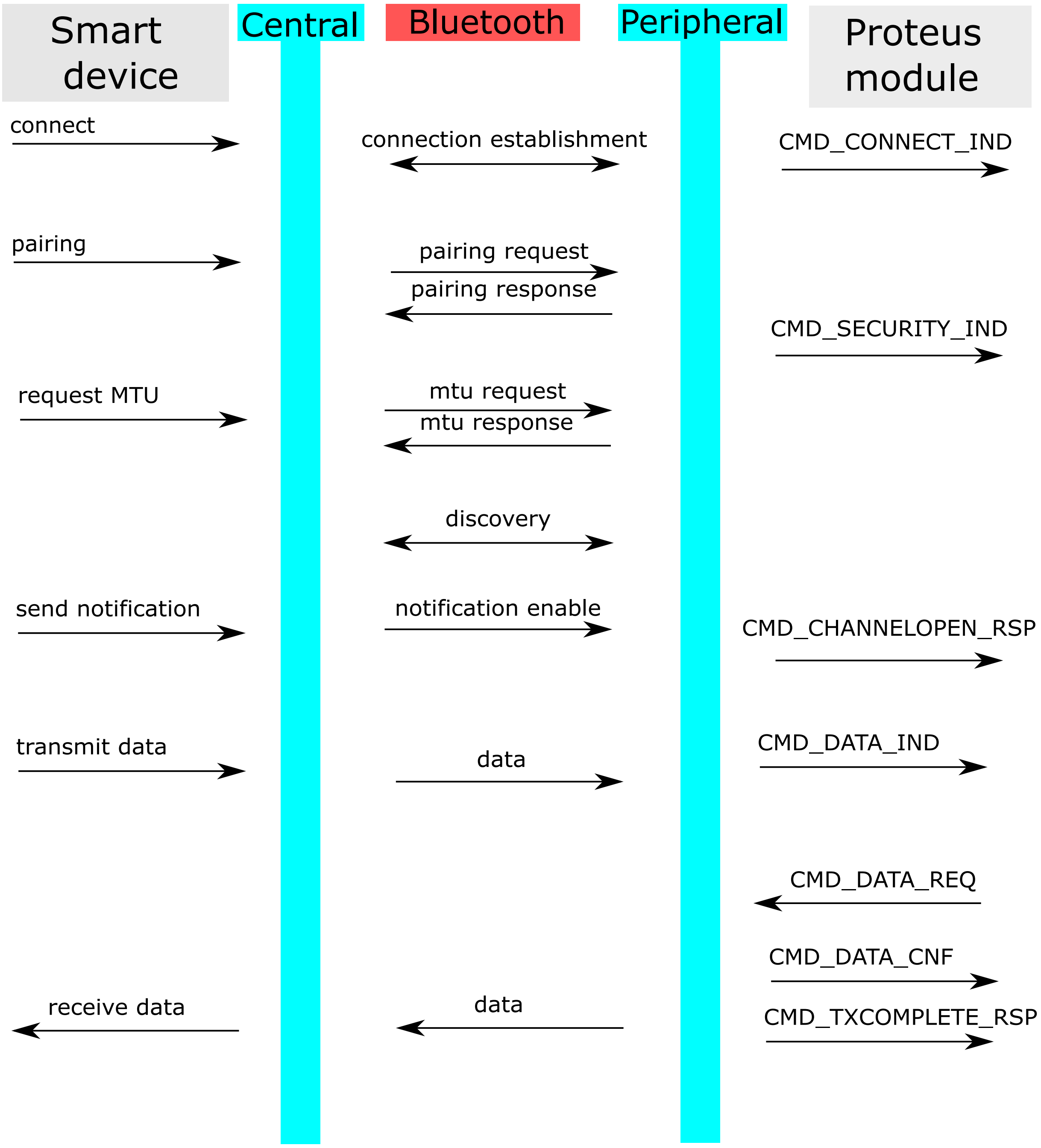


Figure 4: Steps for the connection setup

4 Quick start

The following description demonstrates how to setup a connection with a smart phone to a Proteus radio module. The smart phone acts as central device.
First of all the **Proteus Connect** App is used. Then the same is done using the Nordic Semiconductor **nRF Connect** App.

4.1 Proteus Connect App

This chapter describes how to setup a connection to the Proteus module in command mode, when a smart phone and the Proteus Connect App are used.

> The Proteus Connect App for iOS and Android is provided by Würth Elektronik eiSos as executable [3][4] as well as source code [5][6].

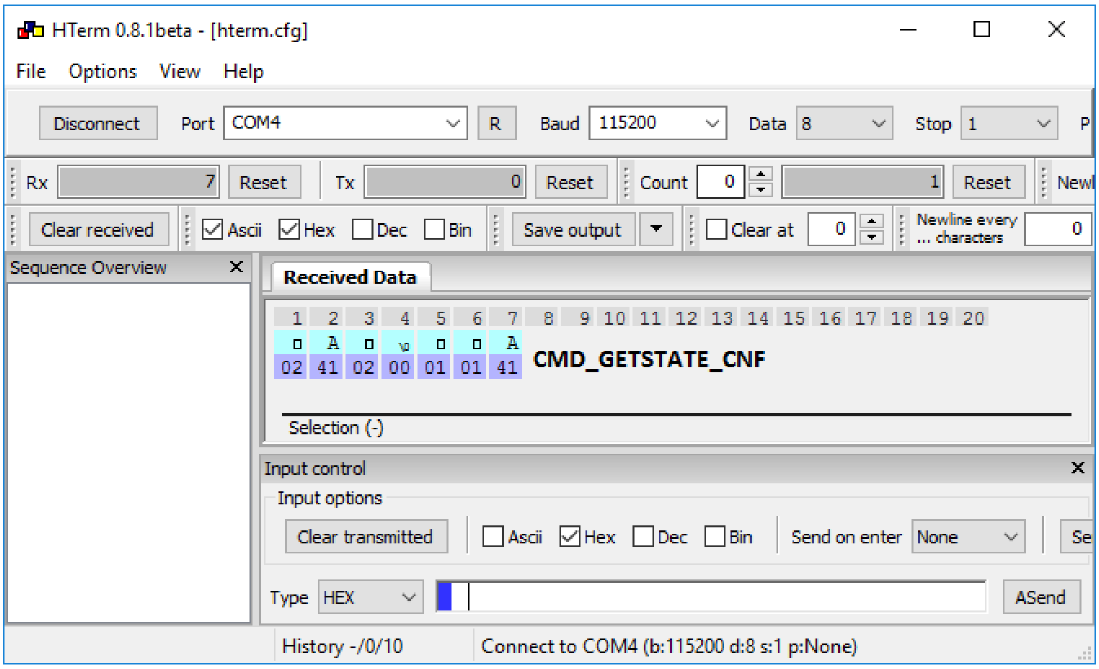
Please perform the following steps:

Android	iOS

- Connect the Proteus evaluation board to a host.
  In this application note, we assume that a Windows PC and the terminal program *hterm* is used. For Proteus-I, -II and -III evaluation board this can be simply achieved by using a simple USB cable to connect it to a PC.
  To make life easy, also the SmartCommander PC tool provided by Würth Elektronik eiSos can be used. This tool implements all commands of the Proteus radio module.

- Open the terminal program using the Proteus default UART settings (115200 Baud, 8n1).

- Press the reset button on the Proteus evaluation board. The Proteus module outputs a `CMD_GETSTATE_CNF` (0x02410200010141) message to indicate that it is ready for operation.



HTerm 0.8.1beta - [hterm.cfg]

Port COM4 · Baud 115200 · Data 8 · Stop 1

Rx 7 · Tx 0 · Count 0 · 1

☑ Ascii ☑ Hex ☐ Dec ☐ Bin · ☐ Clear at 0 · Newline every ... characters 0

Received Data

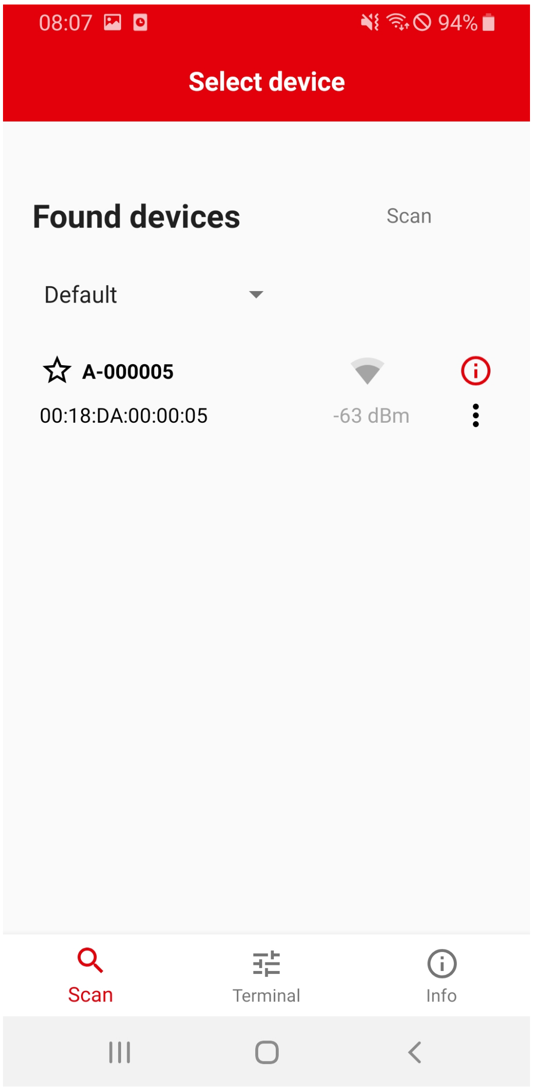
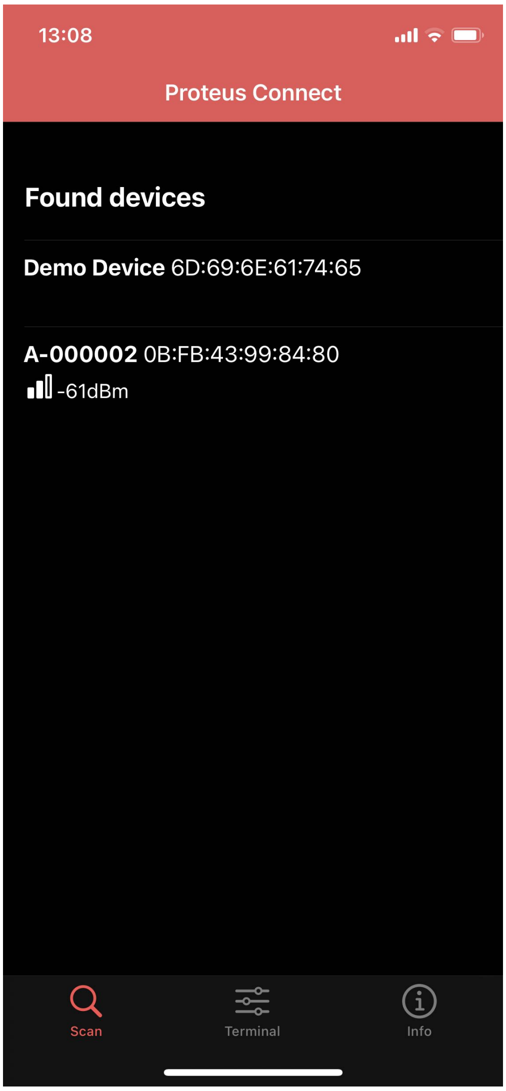
```
 1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20
 □  A  □  \0 □  □  A
02 41 02 00 01 01 41  CMD_GETSTATE_CNF
```

Input options: ☐ Ascii ☑ Hex ☐ Dec ☐ Bin · Send on enter None · Type HEX

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

Android	iOS

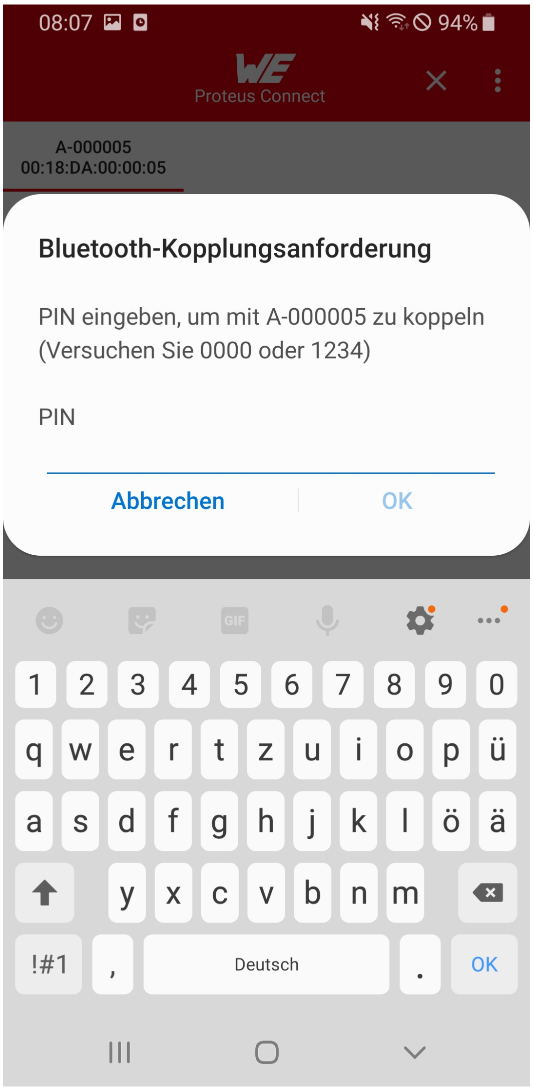
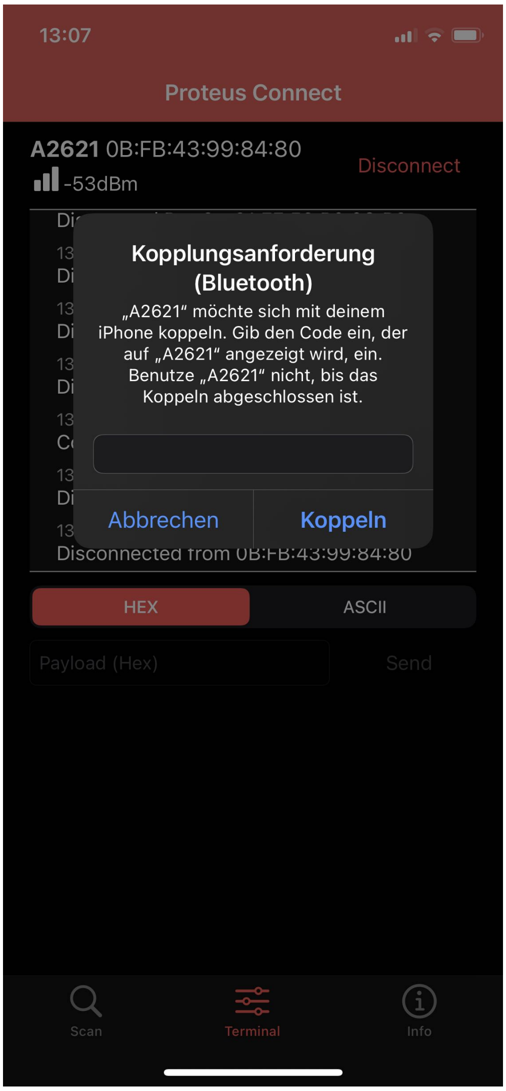
- Initially, the module is advertising. Thus, one LED of the Proteus evaluation board is blinking.
- Start your smart phone, enable the Bluetooth® LE feature and start the **Proteus Connect** App.

Android	iOS
• Press "Scan" to find the module on the radio.  08:07 94% Select device Found devices Scan Default ☆ A-000005 00:18:DA:00:00:05 -63 dBm Scan Terminal Info	 13:08 Proteus Connect Found devices **Demo Device** 6D:69:6E:61:74:65 **A-000002** 0B:FB:43:99:84:80 -61dBm Scan Terminal Info

- When the module appears, select it to start the connection process.
- As soon as the module has received the connection request the module *LED_1* (*LED_3* on the Proteus-EV) will constantly light up.

<table>
<tr><th>Android</th><th>iOS</th></tr>
<tr><td colspan="2">

- Optional pairing: In case a security mode 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 Bluetooth® 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.

</td></tr>
<tr><td>08:07 94%
Proteus Connect
A-000005
00:18:DA:00:00:05
Bluetooth-Kopplungsanforderung
PIN eingeben, um mit A-000005 zu koppeln (Versuchen Sie 0000 oder 1234)
PIN
Abbrechen OK
 </td>
<td>13:07
Proteus Connect
A2621 0B:FB:43:99:84:80 Disconnect
-53dBm
Kopplungsanforderung (Bluetooth)
„A2621“ möchte sich mit deinem iPhone koppeln. Gib den Code ein, der auf „A2621“ angezeigt wird, ein. Benutze „A2621“ nicht, bis das Koppeln abgeschlossen ist.
Abbrechen Koppeln
Disconnected from 0B:FB:43:99:84:80

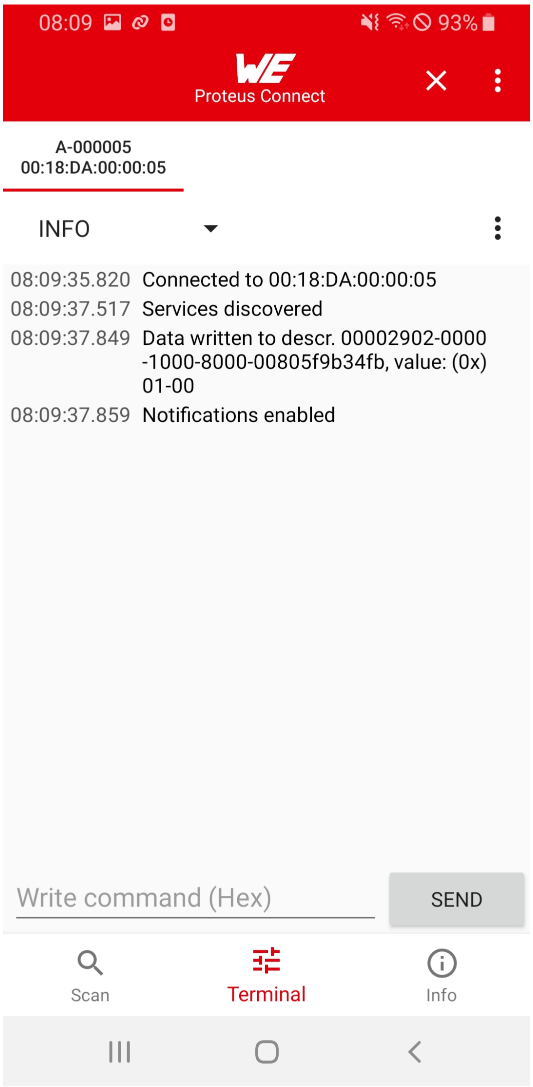
HEX
ASCII
Payload (Hex)
Send
Scan
Terminal
Info

</td></tr>
</table>

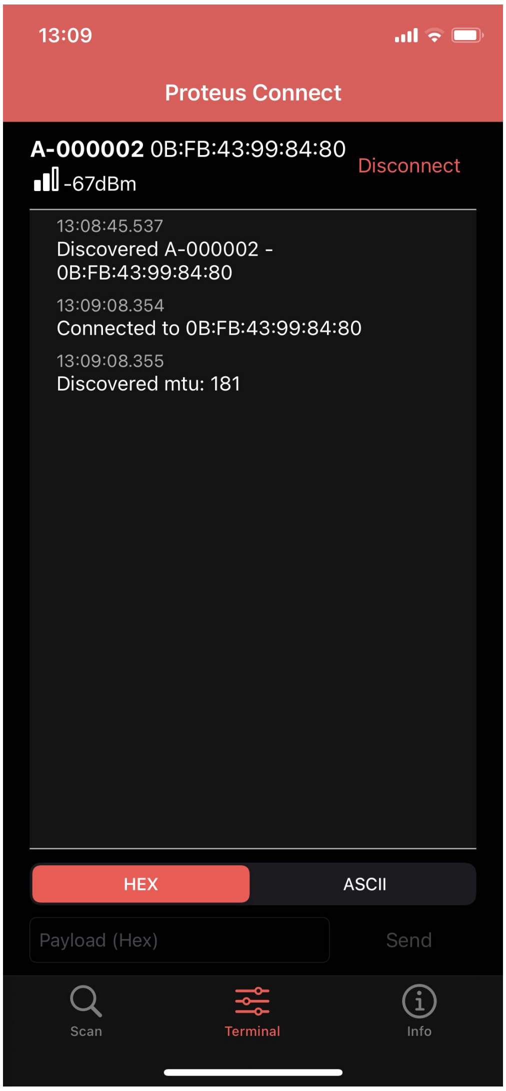
In few cases the Android may show an "authentication timeout" pop-up message, when entering the key. In this case, please proceed entering the key and simply do a reconnect. On this reconnect, the entered key information is reused and the connection is opened.

Android	iOS

- Now you are authenticated and the *LED_2* (*LED_2* on the Proteus-EV) is turned on. Now data can be transmitted in both directions.



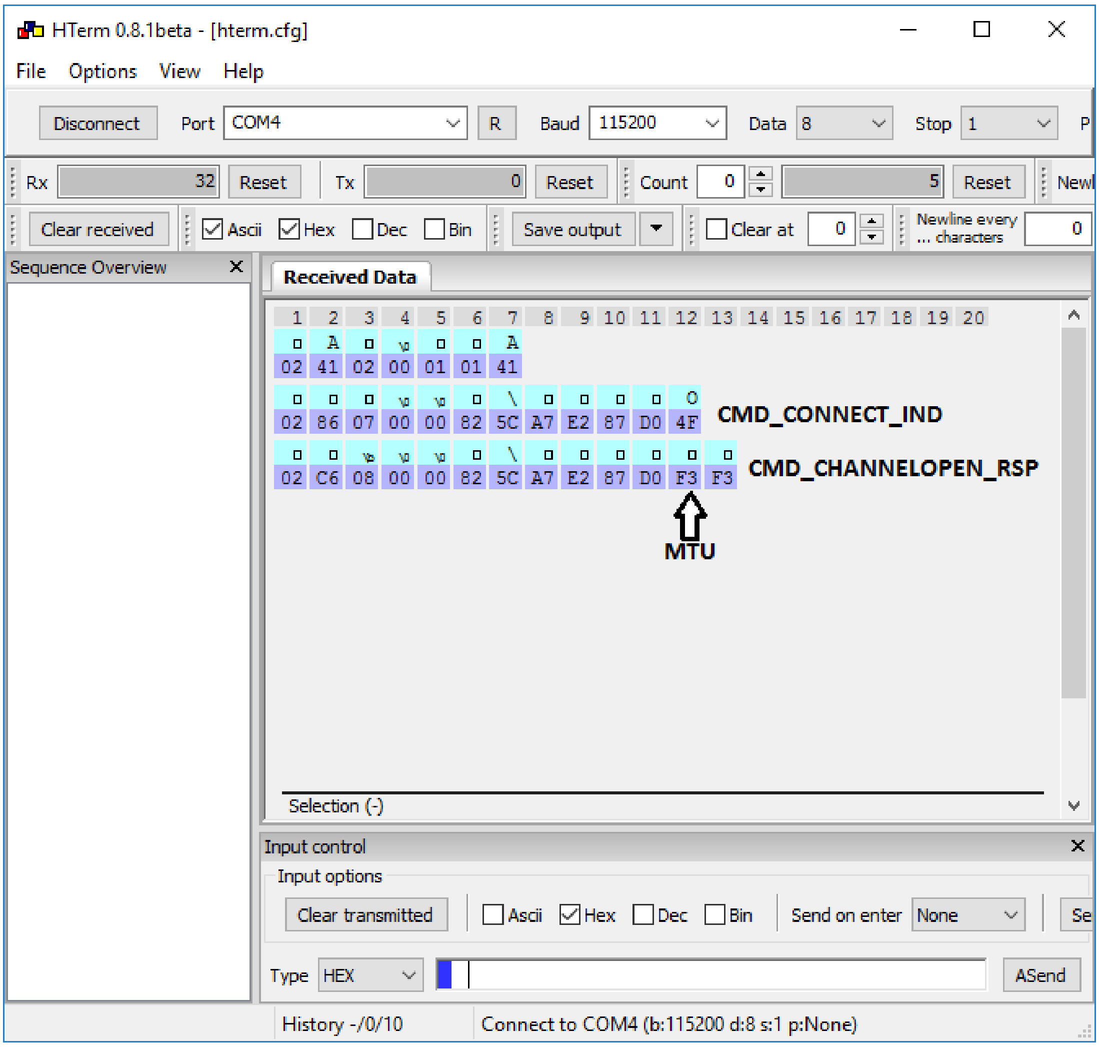
```
08:09:35.820  Connected to 00:18:DA:00:00:05
08:09:37.517  Services discovered
08:09:37.849  Data written to descr. 00002902-0000
              -1000-8000-00805f9b34fb, value: (0x)
              01-00
08:09:37.859  Notifications enabled
```



```
13:08:45.537
Discovered A-000002 -
0B:FB:43:99:84:80
13:09:08.354
Connected to 0B:FB:43:99:84:80
13:09:08.355
Discovered mtu: 181
```

Android	iOS

- 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 length. In this example it's 0xF3 (243$_{dec}$) bytes payload per packet.



Port COM4 | Baud 115200 | Data 8 | Stop 1

Rx 32 | Tx 0 | Count 0 | 5

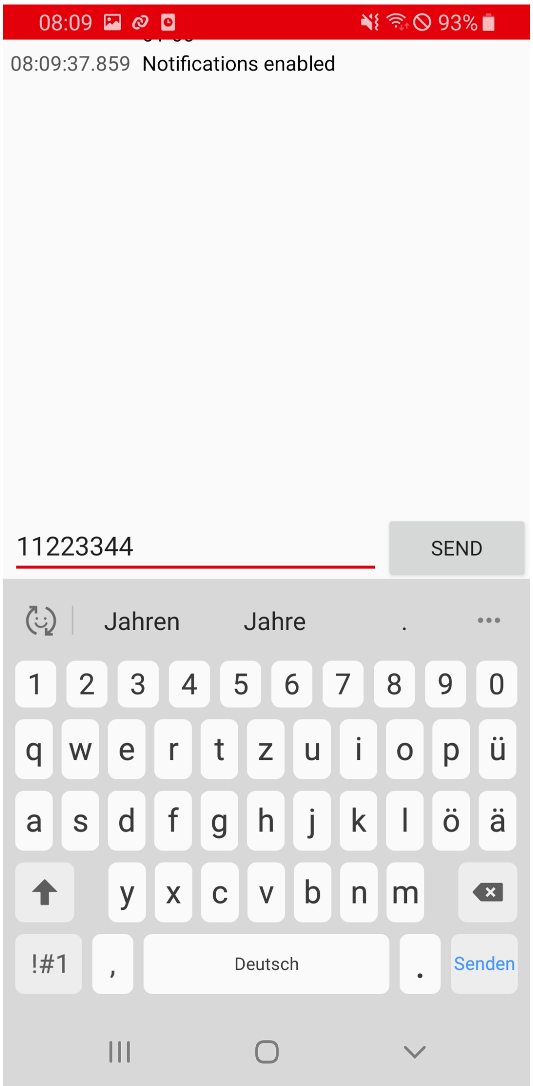
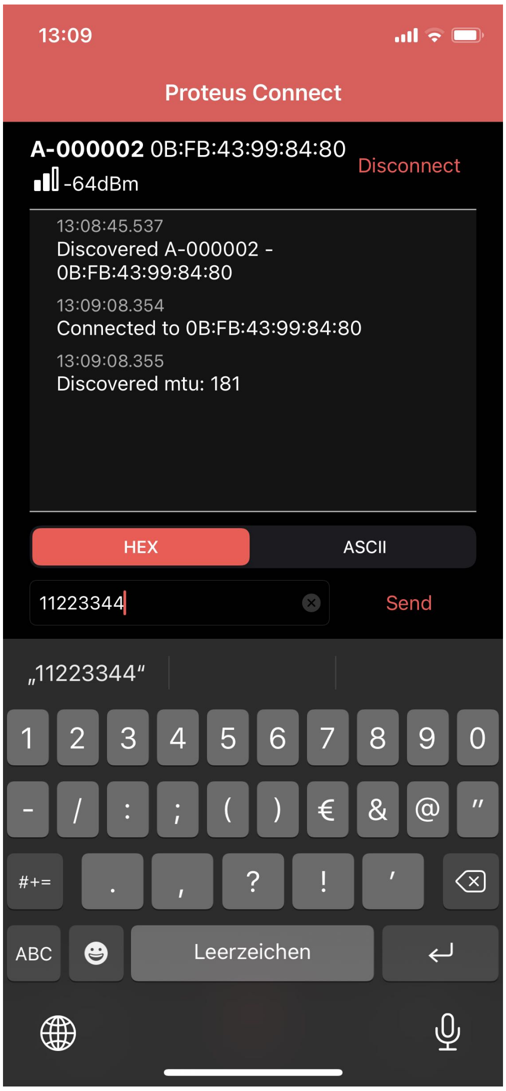
☑ Ascii ☑ Hex □ Dec □ Bin | □ Clear at 0 | Newline every ... characters 0

```
 1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20
 □  A  □  \0 □  □  A
02 41 02 00 01 01 41
 □  □  □  \0 \0 □  \  □  □  □  □  O
02 86 07 00 00 82 5C A7 E2 87 D0 4F
 □  □  \b \0 \0 □  \  □  □  □  □  □  □
02 C6 08 00 00 82 5C A7 E2 87 D0 F3 F3
```

□ Ascii ☑ Hex □ Dec □ Bin | Send on enter None

Type HEX

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

<table>
<tr><th>Android</th><th>iOS</th></tr>
<tr><td colspan="2">• First of all, we want to send data from the smart phone to the radio module. To do so, enter your payload (for example 0x11 0x22 0x33 0x44) in the respective field and press "SEND". The allowed payload size is dependent on the MTU that was negotiated in the connection process. The smallest supported MTU for all Bluetooth® 4.0 (or newer) devices results in a max payload of 19 bytes.</td></tr>
<tr><td>• Android usually allows up to 243 bytes.</td><td>• iOS usually allows up to 181 bytes.</td></tr>
<tr><td>
08:09:37.859 Notifications enabled
11223344
 </td><td>
13:09
Proteus Connect
A-000002 0B:FB:43:99:84:80
-64dBm
13:08:45.537
Discovered A-000002 - 0B:FB:43:99:84:80
13:09:08.354
Connected to 0B:FB:43:99:84:80
13:09:08.355
Discovered mtu: 181
HEX
11223344

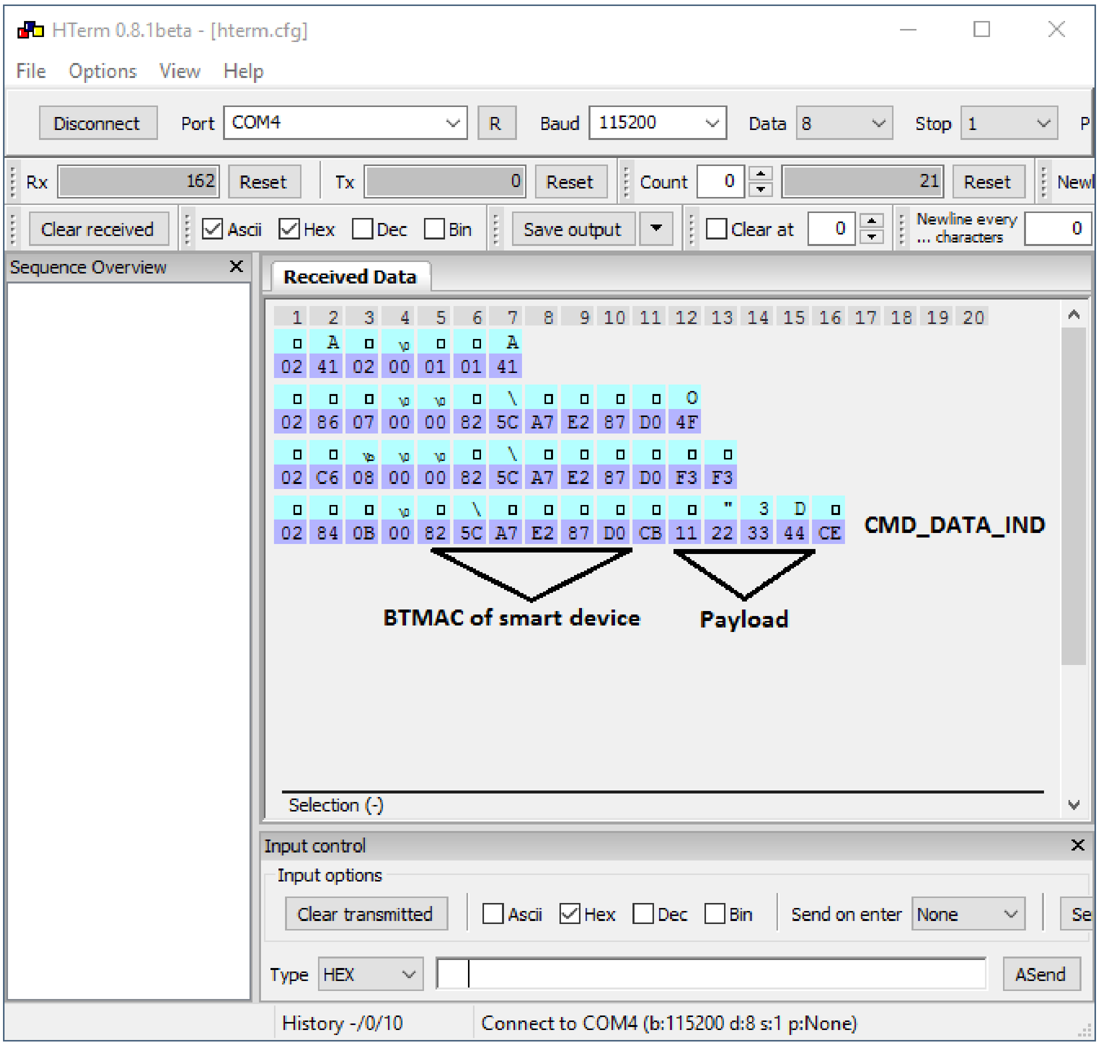
Disconnect
ASCII
Send
„11223344“
Leerzeichen
ABC

</td></tr>
</table>

Android	iOS

- The payload that has been sent is output by the Proteus module via UART. In the terminal program a `CMD_DATA_IND` message has been received that contains the `BTMAC` of the sending device and the transmitted payload 0x11 0x22 0x33 0x44. The format of the `CMD_DATA_IND` message is as follows:

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



Port COM4 Baud 115200 Data 8 Stop 1

Rx 162 Tx 0 Count 0 21

☑ Ascii ☑ Hex □ Dec □ Bin □ Clear at 0 Newline every ... characters 0

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

 □  □  □  \0 \0 □  \  □  □  □  □  O
02 86 07 00 00 82 5C A7 E2 87 D0 4F

 □  □  \b \0 \0 □  \  □  □  □  □  □  □
02 C6 08 00 00 82 5C A7 E2 87 D0 F3 F3

 □  □  □  \0 □  \  □  □  □  □  □  □  "  3  D  □
02 84 0B 00 82 5C A7 E2 87 D0 CB 11 22 33 44 CE
```

□ Ascii ☑ Hex □ Dec □ Bin Send on enter None

Type HEX

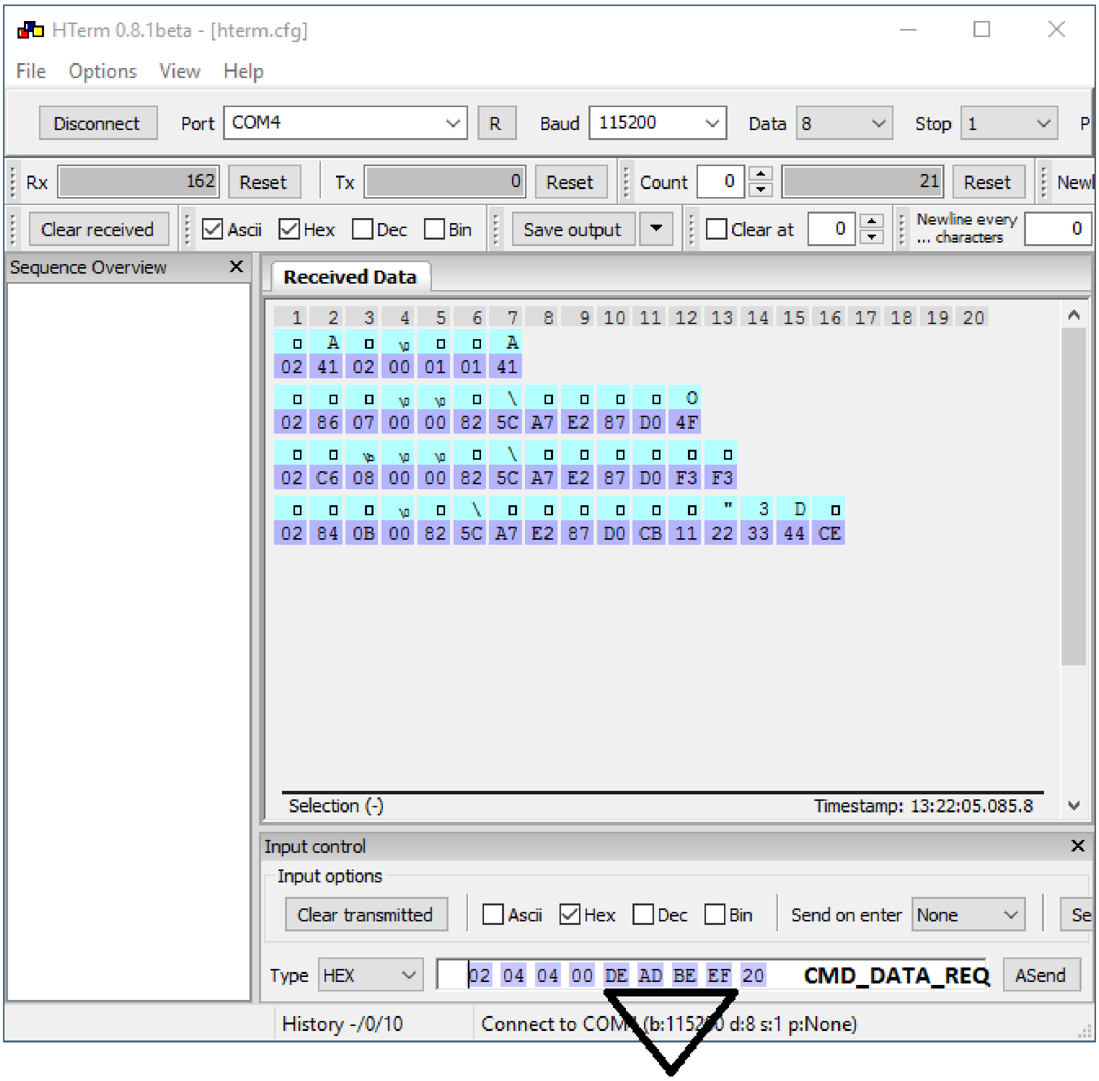
History -/0/10 Connect to COM4 (b:115200 d:8 s:1 p:None)

Android	iOS

- To send back data to the smart phone 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:

Start signal	Command	Length	Payload	CS
0x02	0x04	2 Bytes	Length Bytes	1 Byte
0x02	0x04	0x04 0x00	0xDE 0xAD 0xBE 0xEF	0x20

- 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.



Port COM4 · Baud 115200 · Data 8 · Stop 1

Rx 162 · Tx 0 · Count 0 · 21 · Newline every ... characters 0 · Clear at 0

```
 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
```

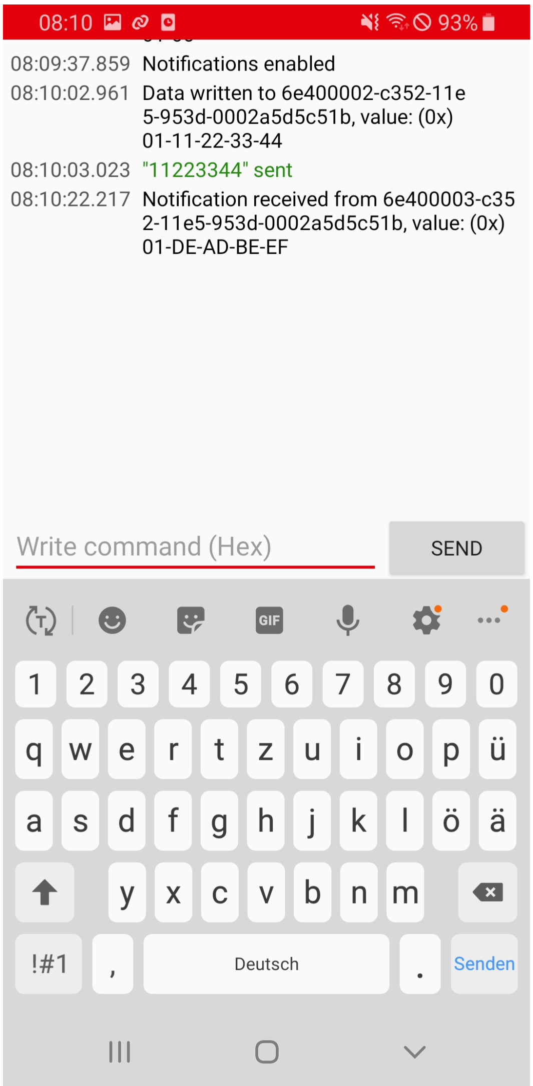
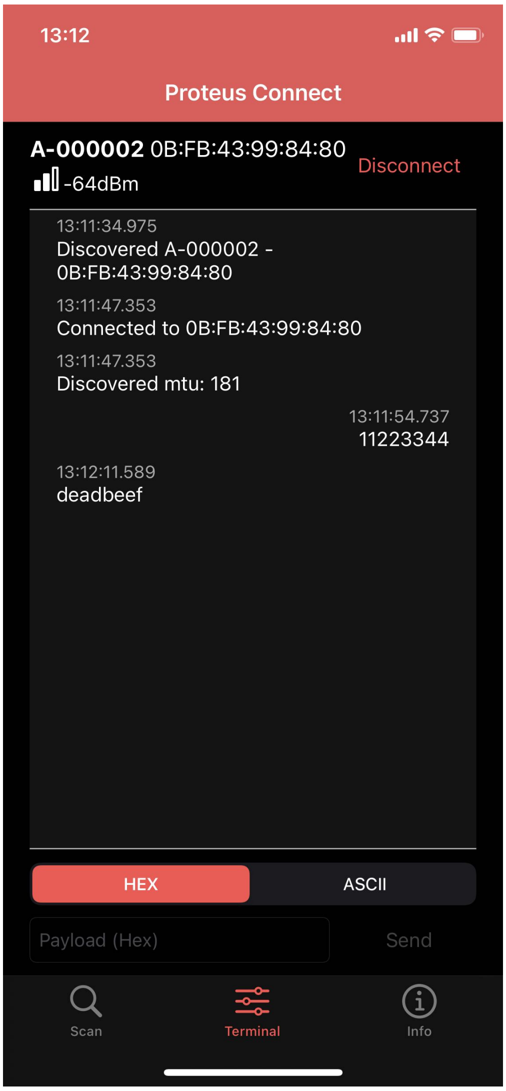
Selection (-) · Timestamp: 13:22:05.085.8

Send on enter None

Type HEX · 02 04 04 00 DE AD BE EF 20 **CMD_DATA_REQ**

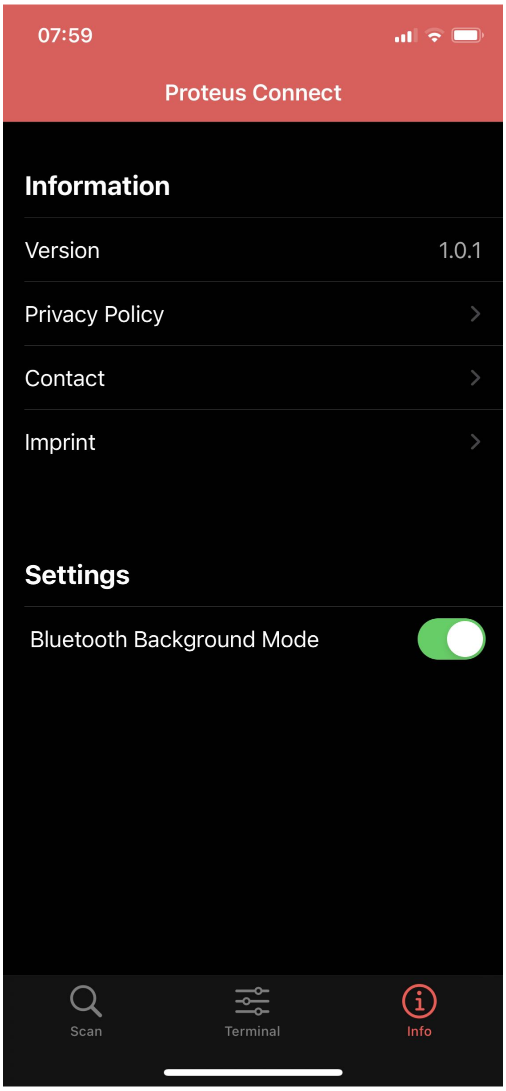
History -/0/10 · Connect to COM4 (b:115200 d:8 s:1 p:None)

Payload, no header 0x01 needed

Android	iOS
• The received data is shown in the status window. It contains the header byte 0x01 and the payload 0xDE 0xAD 0xBE 0xEF, that has been entered in the terminal program.	• The received data is shown in the status window.
 08:10 93% 08:09:37.859 Notifications enabled 08:10:02.961 Data written to 6e400002-c352-11e5-953d-0002a5d5c51b, value: (0x) 01-11-22-33-44 08:10:03.023 "11223344" sent 08:10:22.217 Notification received from 6e400003-c352-11e5-953d-0002a5d5c51b, value: (0x) 01-DE-AD-BE-EF Write command (Hex) SEND	 13:12 Proteus Connect A-000002 0B:FB:43:99:84:80 Disconnect -64dBm 13:11:34.975 Discovered A-000002 - 0B:FB:43:99:84:80 13:11:47.353 Connected to 0B:FB:43:99:84:80 13:11:47.353 Discovered mtu: 181 13:11:54.737 11223344 13:12:11.589 deadbeef HEX ASCII Payload (Hex) Send Scan Terminal Info

4.1.1 Background service on iOS

By default, iOS disconnects the Bluetooth® LE connection, in case the Proteus Connect App is put to background. To avoid this behavior, the background service of the Proteus Connect App must be enabled by going to the info tab and selecting the "Bluetooth Background Mode" slider.



Information

Version 1.0.1

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Settings

Bluetooth Background Mode ●

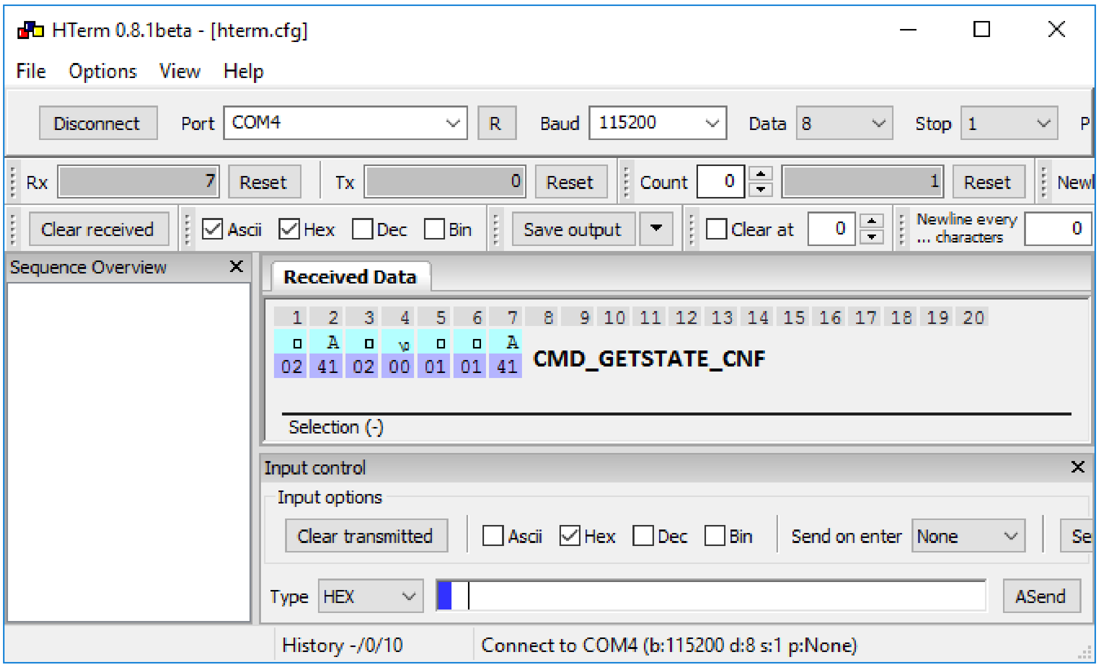
Figure 5: Enable the background service on iOS

4.2 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 [1][2] are used. Please perform the following steps:

Android	iOS

- Connect the Proteus evaluation board to a host.
  In this application note, we assume that a Windows PC and the terminal program *hterm* is used. For Proteus-I, -II and -III evaluation board this can be simply achieved by using a simple USB cable to connect it to a PC.
  To make life easy, also the SmartCommander PC tool provided by Würth Elektronik eiSos can be used. This tool implements all commands of the Proteus radio module.
- Open the terminal program using the Proteus default UART settings (115200 Baud, 8n1).
- Press the reset button on the Proteus evaluation board. The Proteus module outputs a `CMD_GETSTATE_CNF` (0x02410200010141) message to indicate that it is ready for operation.



HTerm 0.8.1beta - [hterm.cfg]

Port COM4 · Baud 115200 · Data 8 · Stop 1

Rx 7 · Tx 0 · Count 0 · 1

☑ Ascii ☑ Hex □ Dec □ Bin · □ Clear at 0 · Newline every ... characters 0

Received Data:

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

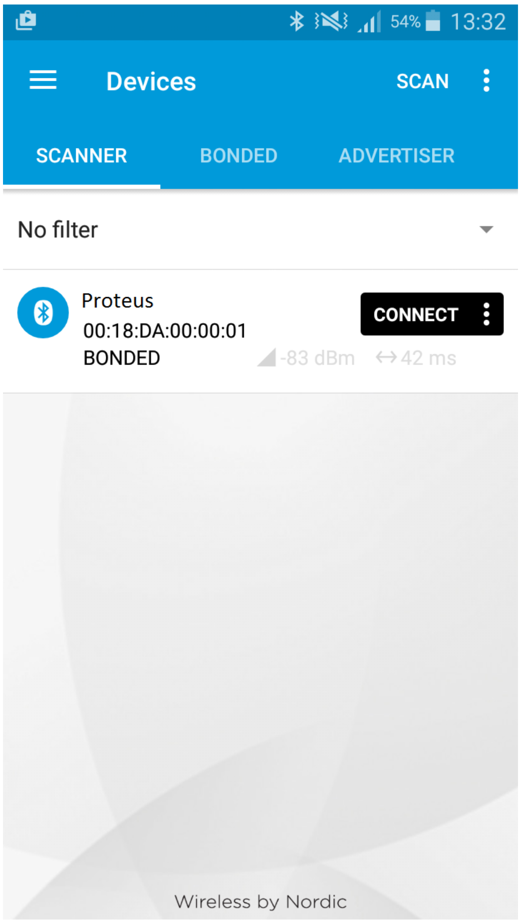
Selection (-)

Input options: □ Ascii ☑ Hex □ Dec □ Bin · Send on enter None · Type HEX

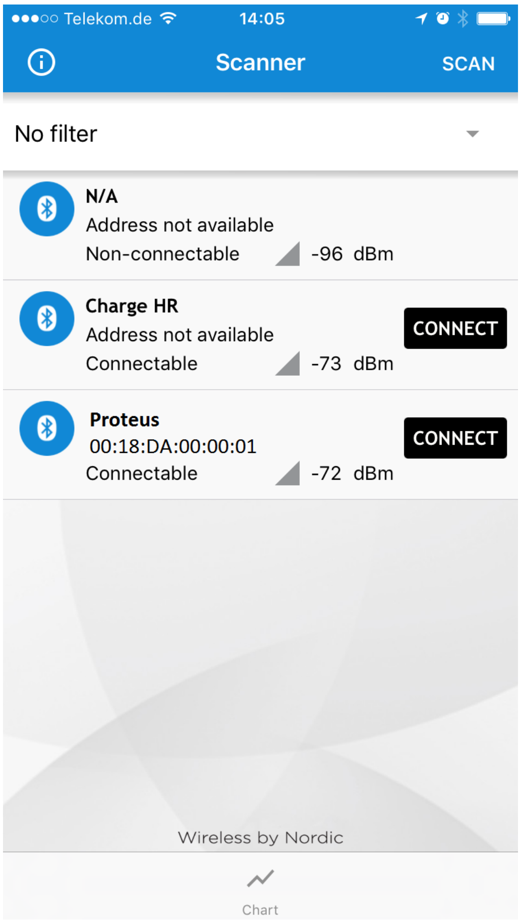
History -/0/10 · Connect to COM4 (b:115200 d:8 s:1 p:None)

Android	iOS

- Initially, the module is advertising. Thus, one LED of the Proteus evaluation board is blinking.
- Start your smart phone, enable the Bluetooth® LE 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 0x0018DAxxxxxx 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.



Proteus
00:18:DA:00:00:01
BONDED
-83 dBm ↔ 42 ms



N/A
Address not available
Non-connectable -96 dBm

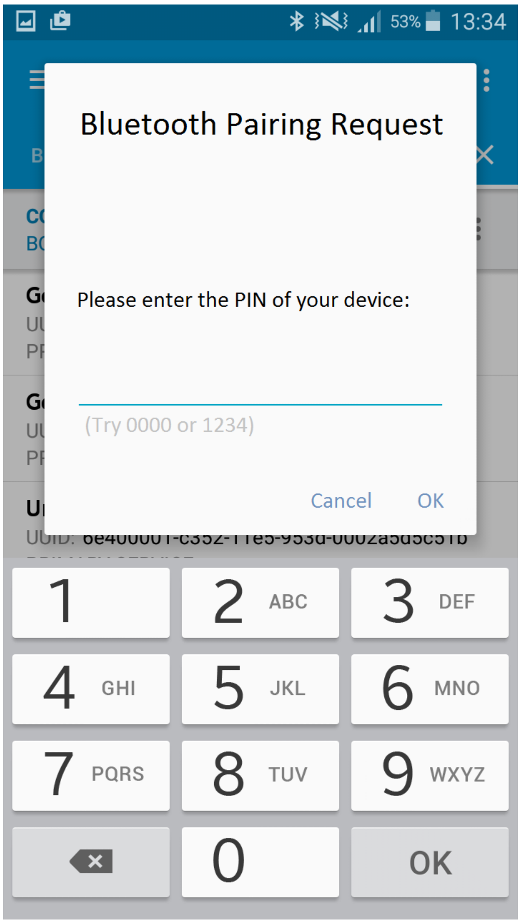
Charge HR
Address not available
Connectable -73 dBm

Proteus
00:18:DA:00:00:01
Connectable -72 dBm

- When the module appears, press "CONNECT".

Android	iOS

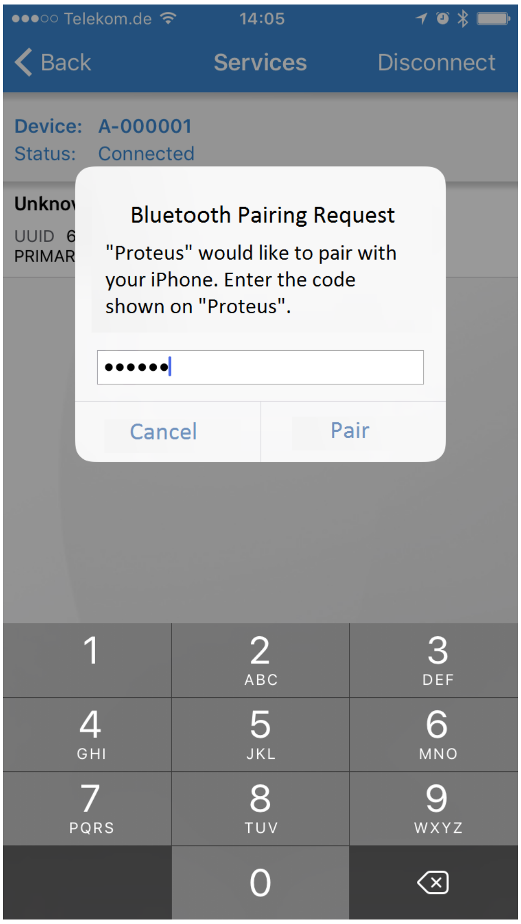
- As soon as the module has received the connection request from the smart phone the blinking LED will switch to constant on.
- Optional pairing: In case a security mode has been configured before, the smart phone requests the user for pairing actions. In case of the static passkey authentication, the Proteus requests to enter the static passkey. The default passkey is "123123". The Bluetooth® 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.



Bluetooth Pairing Request

Please enter the PIN of your device:

(Try 0000 or 1234)

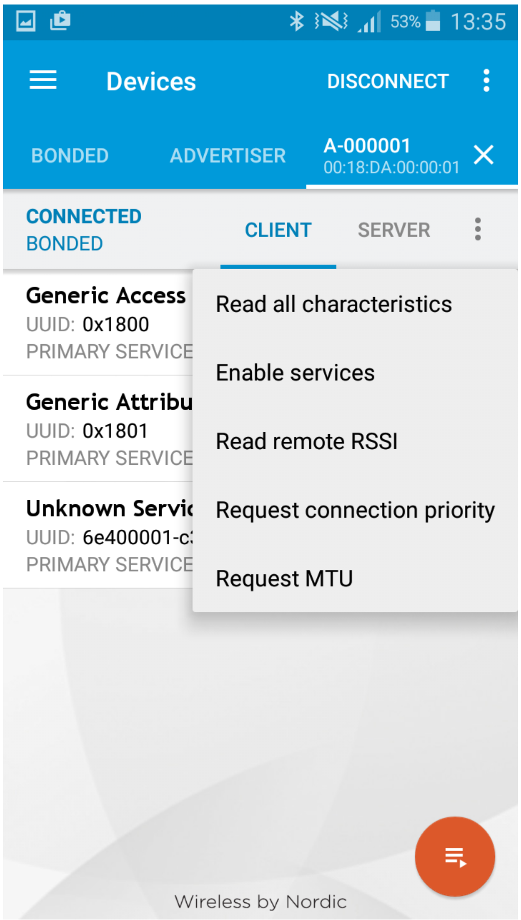
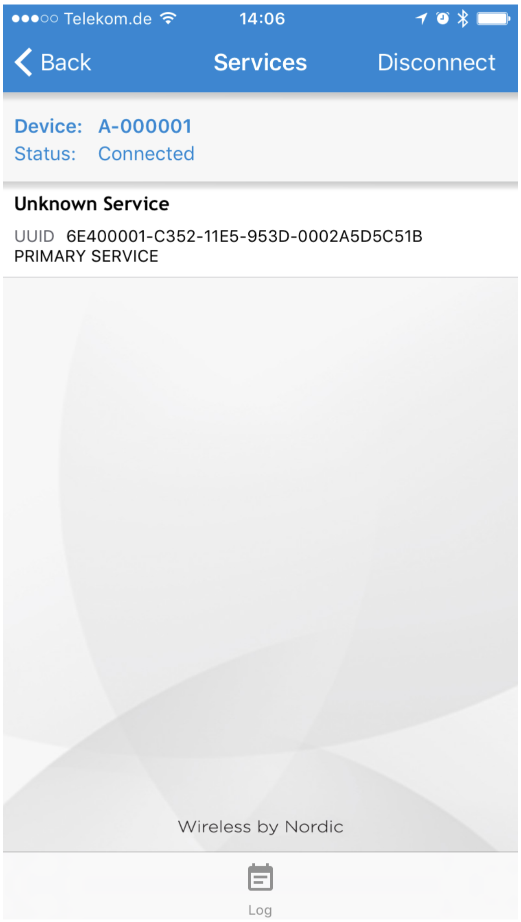


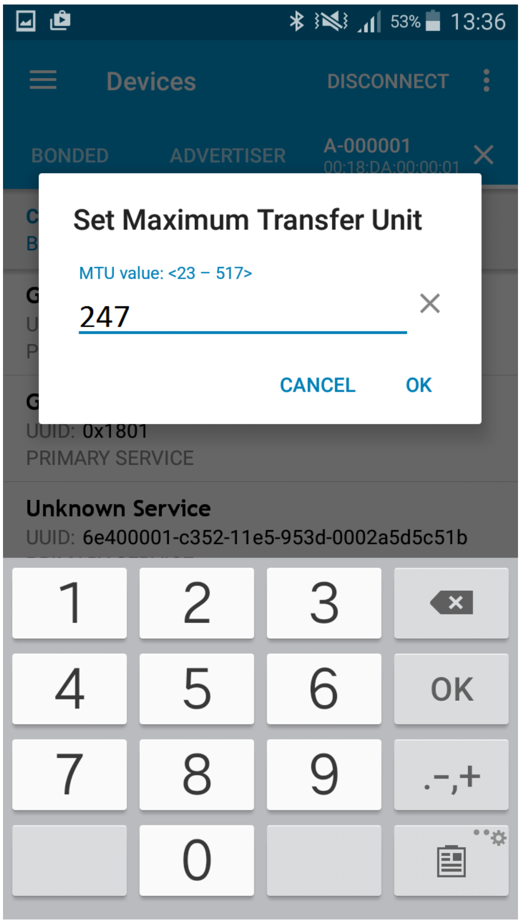
Device: A-000001
Status: Connected

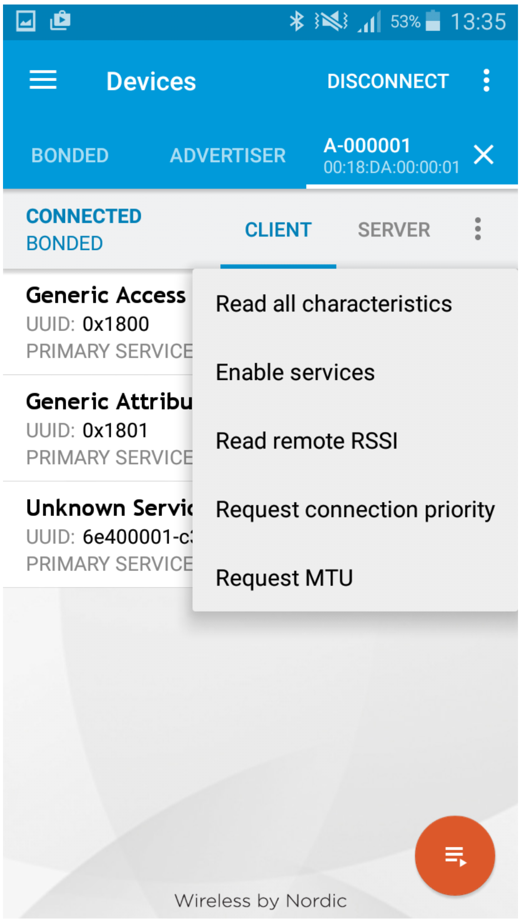
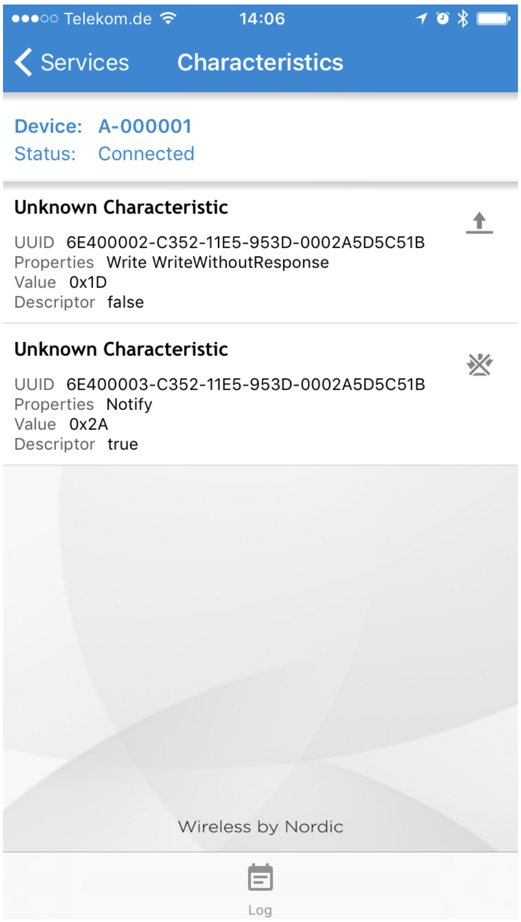
Bluetooth Pairing Request

"Proteus" would like to pair with your iPhone. Enter the code shown on "Proteus".

••••••

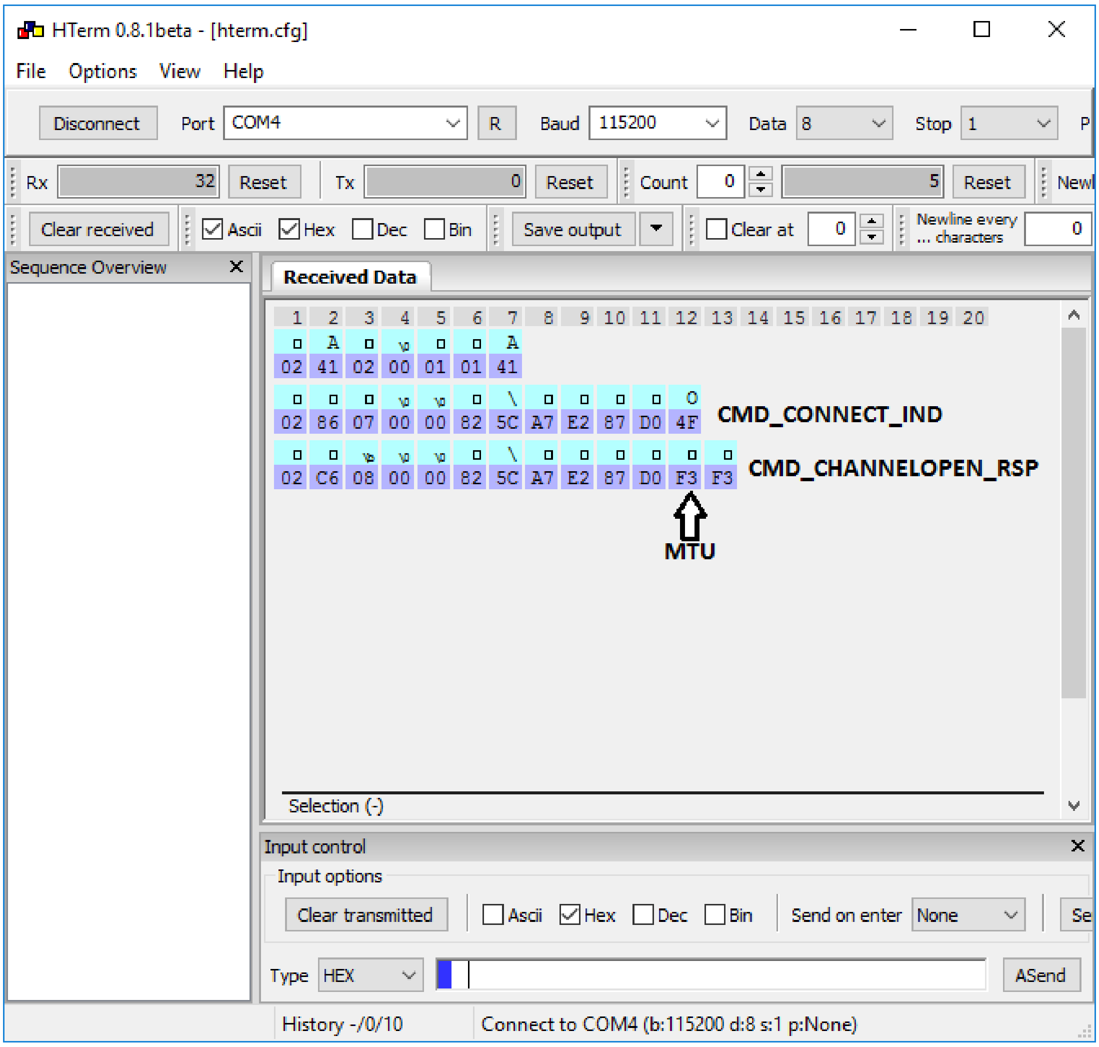
Android	iOS
• Please click on the menu bullets on the right and press "Request MTU" to request for a larger MTU.  53% 13:35 Devices DISCONNECT BONDED ADVERTISER A-000001 00:18:DA:00:00:01 ✕ CONNECTED BONDED CLIENT SERVER Generic Access UUID: 0x1800 PRIMARY SERVICE Generic Attribu UUID: 0x1801 PRIMARY SERVICE Unknown Servic UUID: 6e400001-c PRIMARY SERVICE Read all characteristics Enable services Read remote RSSI Request connection priority Request MTU Wireless by Nordic	• Please click on the "Unknown Service" to start the service discovery and the MTU request.  ●●●○○ Telekom.de 14:06 Back Services Disconnect Device: A-000001 Status: Connected Unknown Service UUID 6E400001-C352-11E5-953D-0002A5D5C51B PRIMARY SERVICE Wireless by Nordic Log

Android	iOS
- The Proteus module allows a MTU of up to 247 bytes, which results in a payload size of 243 bytes.  Set Maximum Transfer Unit MTU value: <23 – 517> 247 CANCEL OK	- The iOS App runs this step simultaneously in the background, a user-defined MTU is not possible.

<table>
<tr><th>Android</th><th>iOS</th></tr>
<tr><td>- Again click on the menu bullets on the right and press "Enable services" to enable the notifications.</td><td>- 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.</td></tr>
<tr><td>
53% 13:35
Devices DISCONNECT
BONDED ADVERTISER A-000001 00:18:DA:00:00:01
CONNECTED BONDED CLIENT SERVER
Generic Access UUID: 0x1800 PRIMARY SERVICE
Generic Attribu UUID: 0x1801 PRIMARY SERVICE
Unknown Servic UUID: 6e400001-c: PRIMARY SERVICE
Read all characteristics
Enable services
Read remote RSSI
Request connection priority
Request MTU
Wireless by Nordic</td><td>
●●●○○ Telekom.de 14:06
Services Characteristics
Device: A-000001
Status: Connected
Unknown Characteristic
UUID 6E400002-C352-11E5-953D-0002A5D5C51B
Properties Write WriteWithoutResponse
Value 0x1D
Descriptor false
Unknown Characteristic
UUID 6E400003-C352-11E5-953D-0002A5D5C51B
Properties Notify
Value 0x2A
Descriptor true
Wireless by Nordic
Log</td></tr>
<tr><td colspan="2">- 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.</td></tr>
</table>

Android	iOS

- 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 length. In this example it's 0xF3 (243_{dec}) bytes payload per packet.



HTerm 0.8.1beta - [hterm.cfg]

Port: COM4 · Baud: 115200 · Data: 8 · Stop: 1

Rx: 32 · Tx: 0 · Count: 0 · 5

☑ Ascii ☑ Hex □ Dec □ Bin · □ Clear at 0 · Newline every ... characters: 0

```
 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        CMD_CONNECT_IND
02 C6 08 00 00 82 5C A7 E2 87 D0 F3 F3     CMD_CHANNELOPEN_RSP
                                 ⇧
                                MTU
```

Selection (-)

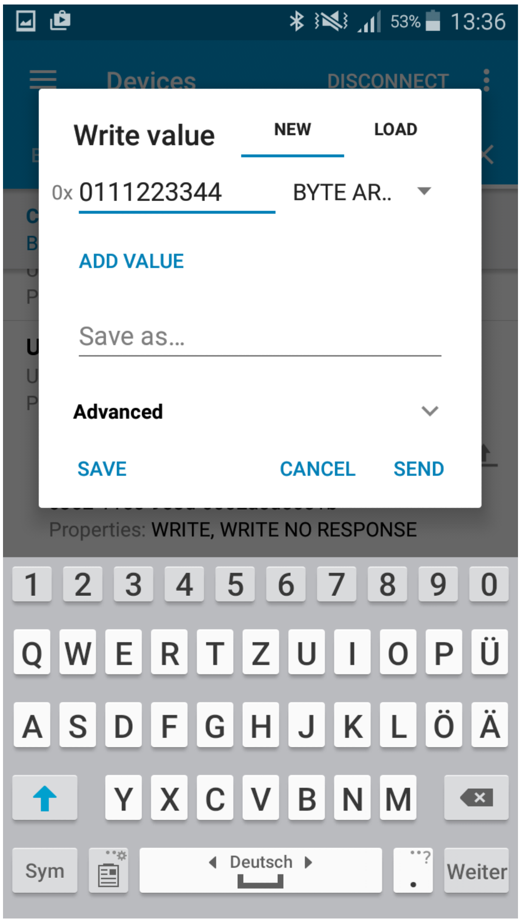
Input options: □ Ascii ☑ Hex □ Dec □ Bin · Send on enter: None · Type: HEX

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

<table>
<tr><th>Android</th><th>iOS</th></tr>
<tr><td colspan="2">

- 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 `CMD_CHANNELOPEN_RSP` message on the previous page).

</td></tr>
<tr><td>

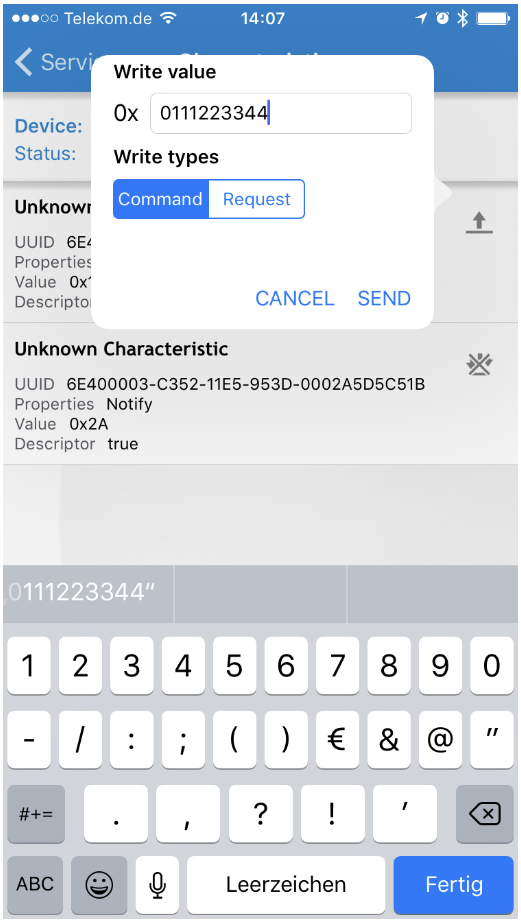


Write value

0x 0111223344 BYTE AR..

Properties: WRITE, WRITE NO RESPONSE

</td><td>



Write value

0x 0111223344

Write types: Command | Request

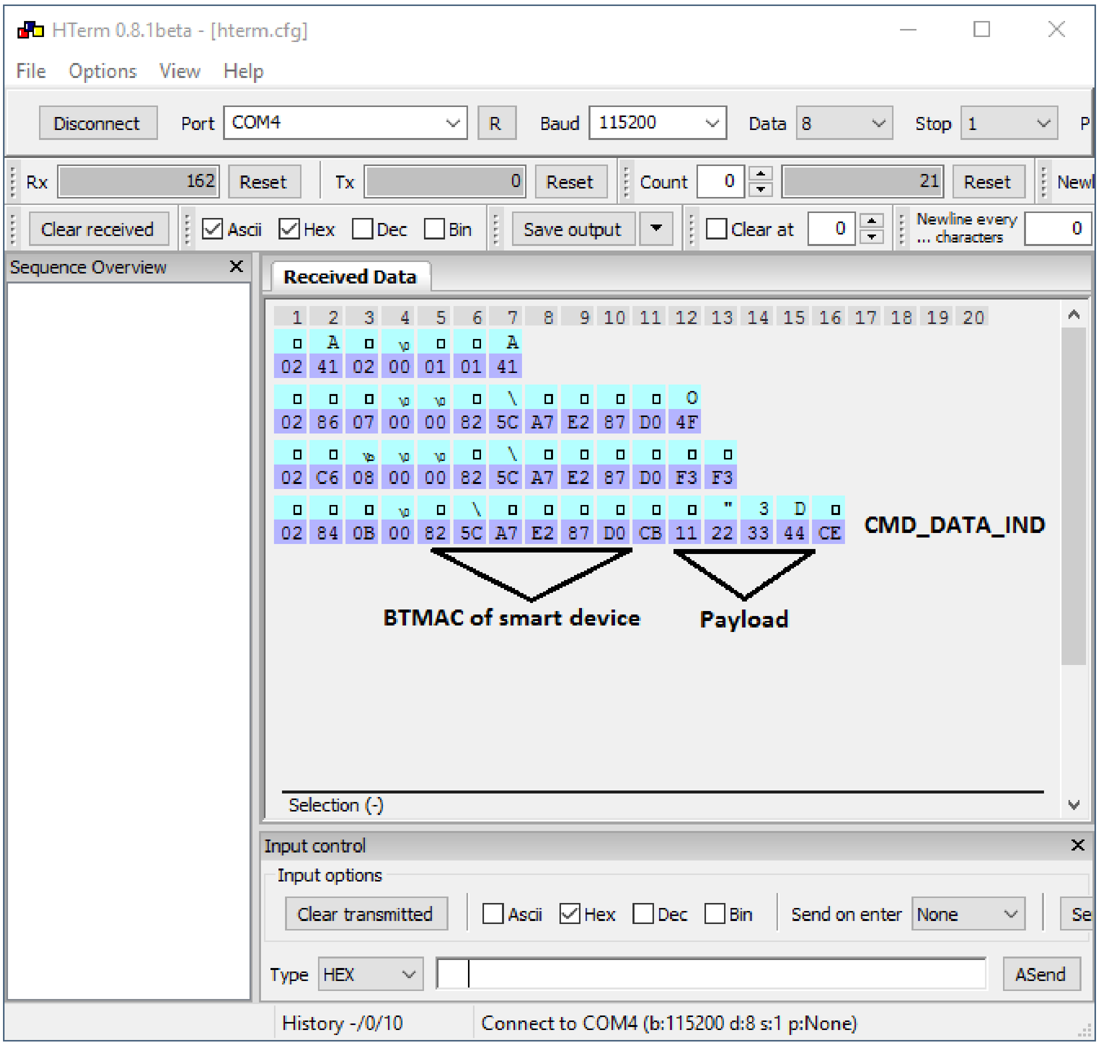
Unknown Characteristic
UUID 6E400003-C352-11E5-953D-0002A5D5C51B
Properties Notify
Value 0x2A
Descriptor true

</td></tr>
</table>

Android	iOS

- The payload that has been sent is output by the Proteus module via UART. In the terminal program a `CMD_DATA_IND` message has been received that contains the `BTMAC` of the sending device and the transmitted payload 0x11 0x22 0x33 0x44. The format of the `CMD_DATA_IND` message is as follows:

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]

Port COM4, Baud 115200, Data 8, Stop 1

Rx 162, Tx 0, Count 0, 21

☑ Ascii ☑ Hex ☐ Dec ☐ Bin

Received Data

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

 □  □  □ \0 \0  □  \  □  □  □  □  O
02 86 07 00 00 82 5C A7 E2 87 D0 4F

 □  □  □ \0 \0  □  \  □  □  □  □  □  □
02 C6 08 00 00 82 5C A7 E2 87 D0 F3 F3

 □  □  □ \0  □  \  □  □  □  □  □  □  "  3  D  □
02 84 0B 00 82 5C A7 E2 87 D0 CB 11 22 33 44 CE
```

Input options: ☐ Ascii ☑ Hex ☐ Dec ☐ Bin, Send on enter None, Type HEX

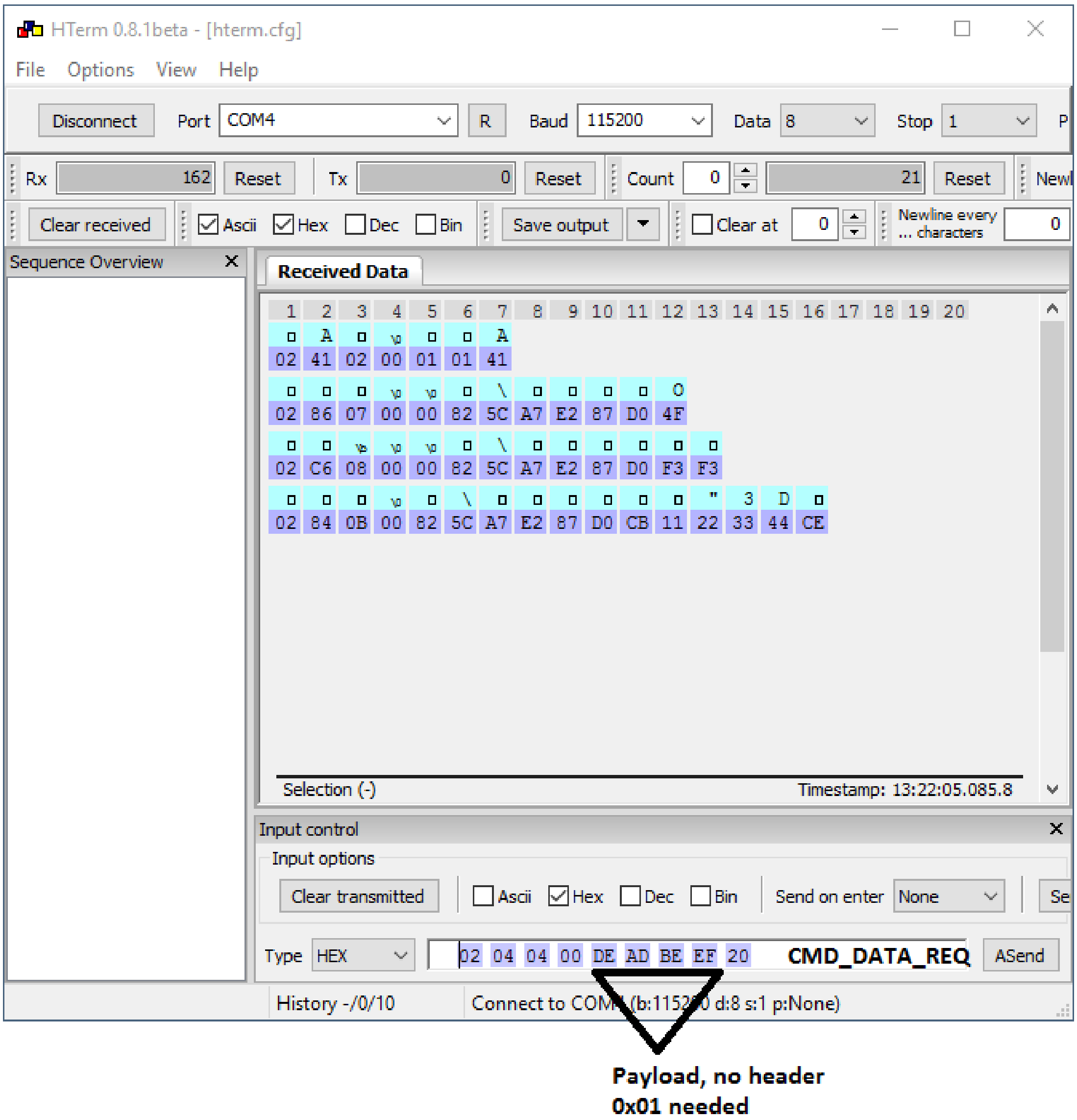
History -/0/10 Connect to COM4 (b:115200 d:8 s:1 p:None)

Android	iOS

- To send back data to the smart phone 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:

Start signal	Command	Length	Payload	CS
0x02	0x04	2 Bytes	Length Bytes	1 Byte
0x02	0x04	0x04 0x00	0xDE 0xAD 0xBE 0xEF	0x20

- 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.



Port COM4 Baud 115200 Data 8 Stop 1

Rx 162 Tx 0 Count 0 21

☑ Ascii ☑ Hex □ Dec □ Bin □ Clear at 0 Newline every ... characters 0

```
 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
```

Selection (-) Timestamp: 13:22:05.085.8

□ Ascii ☑ Hex □ Dec □ Bin Send on enter None

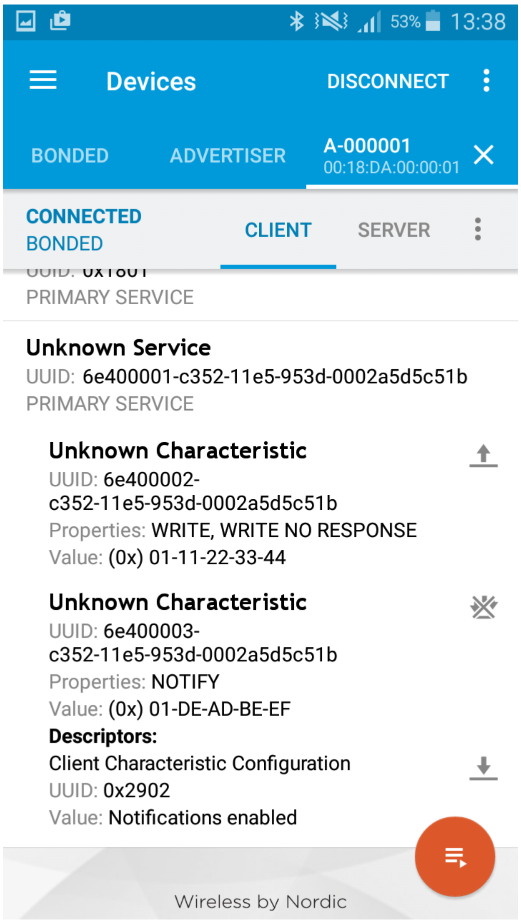
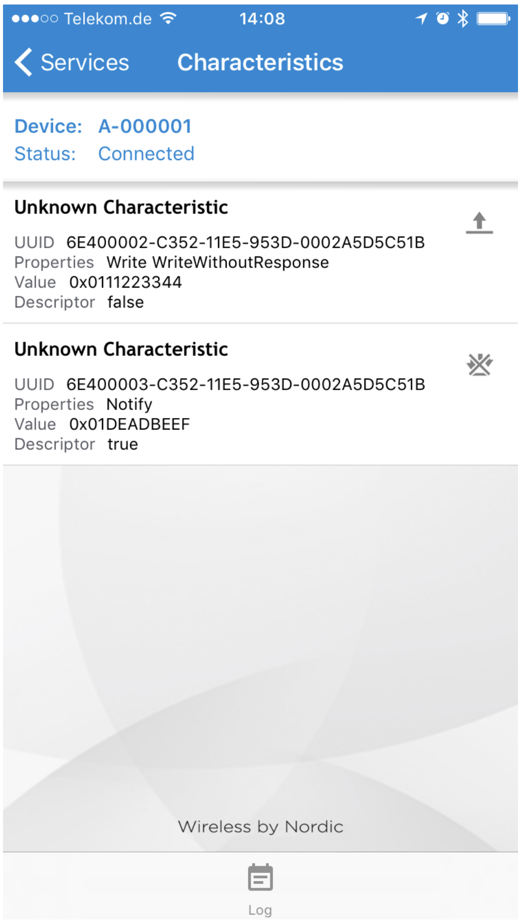
Type HEX `02 04 04 00 DE AD BE EF 20` **CMD_DATA_REQ**

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

Payload, no header 0x01 needed

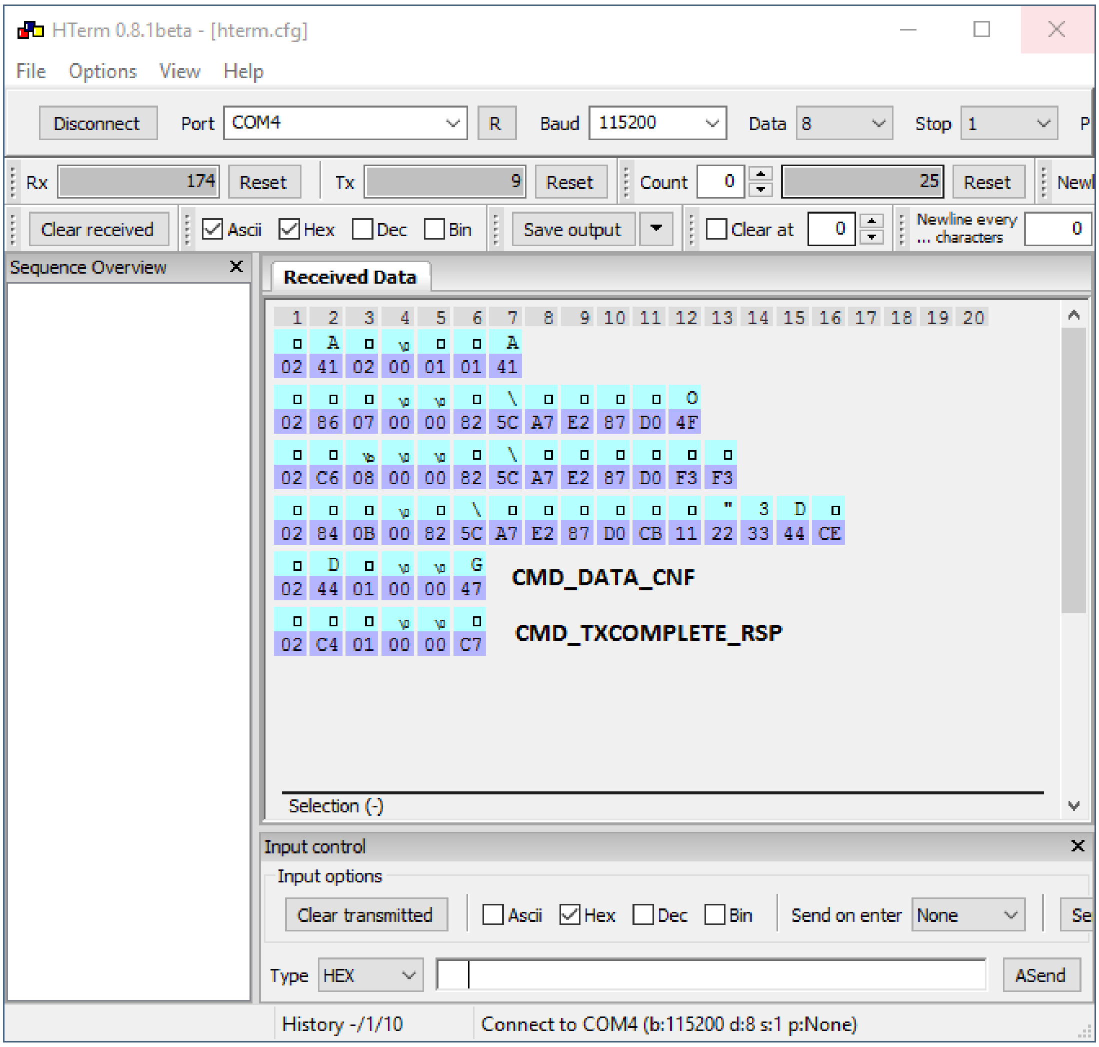
<table>
<tr><th>Android</th><th>iOS</th></tr>
<tr><td colspan="2">

- 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.

</td></tr>
<tr><td>

53% 13:38
Devices DISCONNECT
BONDED ADVERTISER A-000001 00:18:DA:00:00:01
CONNECTED
BONDED
CLIENT SERVER
UUID: 0x1801
PRIMARY SERVICE
Unknown Service
UUID: 6e400001-c352-11e5-953d-0002a5d5c51b
PRIMARY SERVICE
Unknown Characteristic
UUID: 6e400002-c352-11e5-953d-0002a5d5c51b
Properties: WRITE, WRITE NO RESPONSE
Value: (0x) 01-11-22-33-44
Unknown Characteristic
UUID: 6e400003-c352-11e5-953d-0002a5d5c51b
Properties: NOTIFY
Value: (0x) 01-DE-AD-BE-EF
Descriptors:
Client Characteristic Configuration
UUID: 0x2902
Value: Notifications enabled
Wireless by Nordic
</td><td>

●●●○○ Telekom.de 14:08
Services Characteristics
Device: A-000001
Status: Connected
Unknown Characteristic
UUID 6E400002-C352-11E5-953D-0002A5D5C51B
Properties Write WriteWithoutResponse
Value 0x0111223344
Descriptor false
Unknown Characteristic
UUID 6E400003-C352-11E5-953D-0002A5D5C51B
Properties Notify
Value 0x01DEADBEEF
Descriptor true
Wireless by Nordic
Log
</td></tr>
</table>

<table>
<tr><th>Android</th><th>iOS</th></tr>
<tr><td colspan="2">

- 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.



HTerm 0.8.1beta - [hterm.cfg]

Port COM4 Baud 115200 Data 8 Stop 1

Rx 174 Tx 9 Count 0 25

☑ Ascii ☑ Hex ☐ Dec ☐ Bin ☐ Clear at 0 Newline every ... characters 0

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
02 44 01 00 00 47    CMD_DATA_CNF
02 C4 01 00 00 C7    CMD_TXCOMPLETE_RSP
```

Input options: ☐ Ascii ☑ Hex ☐ Dec ☐ Bin Send on enter None

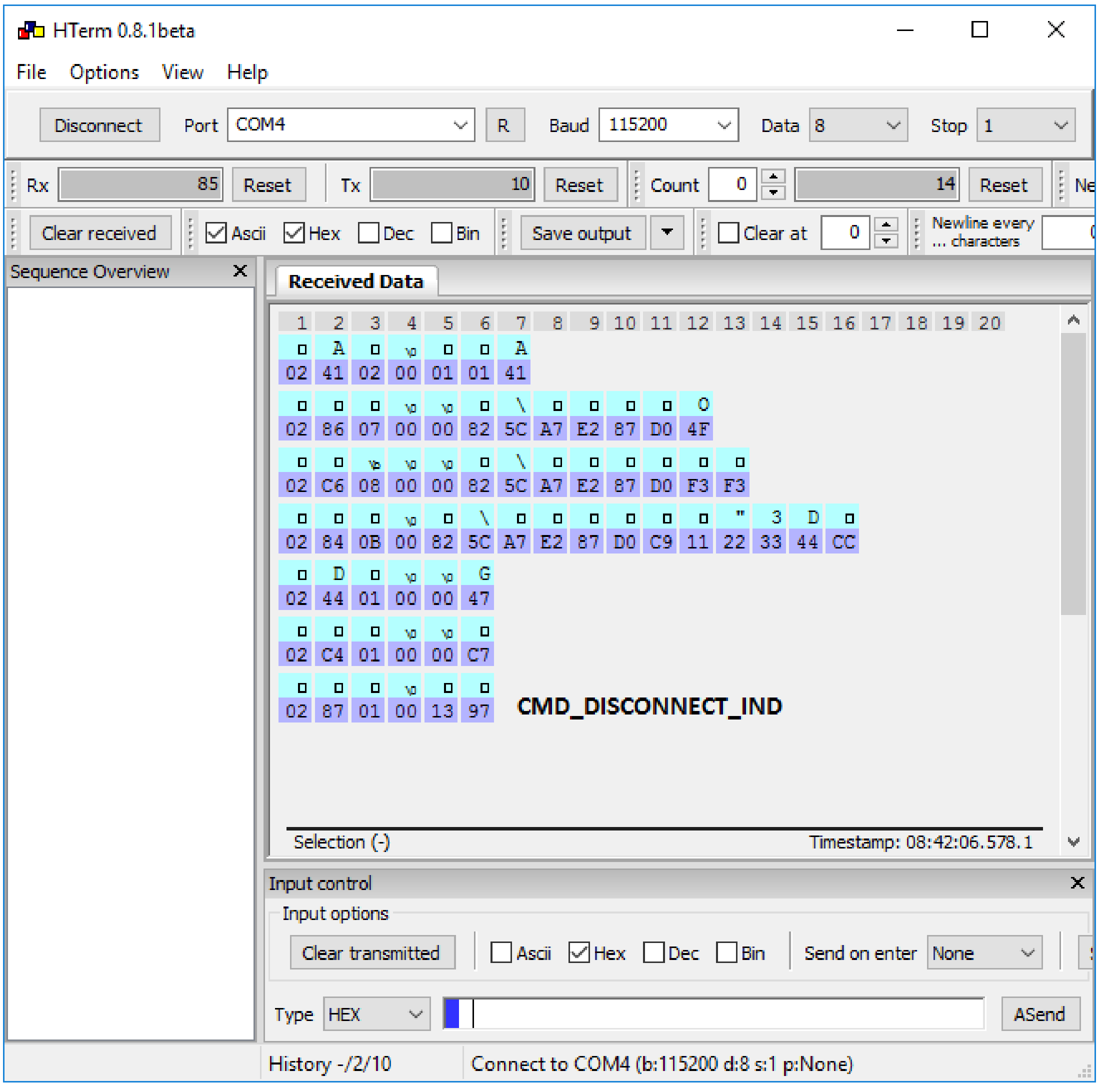
Type HEX

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

</td></tr>
</table>

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.



Port COM4 Baud 115200 Data 8 Stop 1

Rx 85 Tx 10 Count 0 14

☑ Ascii ☑ Hex □ Dec □ Bin □ Clear at 0 Newline every ... characters

```
 1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20
 □  A  □     □  □  A
02 41 02 00 01 01 41
 □  □  □        □  \  □  □  □  □  O
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
 □  □  □     □  \  □  □  □  □  □  □  "  3  D  □
02 84 0B 00 82 5C A7 E2 87 D0 C9 11 22 33 44 CC
 □  D  □        G
02 44 01 00 00 47
 □  □  □        □
02 C4 01 00 00 C7
 □  □  □     □  □
02 87 01 00 13 97   CMD_DISCONNECT_IND
```

Selection (-) Timestamp: 08:42:06.578.1

Input options: □ Ascii ☑ Hex □ Dec □ Bin Send on enter None

Type HEX

History -/2/10 Connect to COM4 (b:115200 d:8 s:1 p:None)

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

5 References

[1] Nordic Semiconductor. nRF Connect app for Android. https://play.google.com/store/apps/details?id=no.nordicsemi.android.mcp.

[2] Nordic Semiconductor. nRF Connect app for iOS. https://apps.apple.com/us/app/nrf-connect-for-mobile/id1054362403.

[3] Würth Elektronik. Proteus Connect app for Android. https://play.google.com/store/apps/details?id=com.eisos.android.terminal.

[4] Würth Elektronik. Proteus Connect app for iOS. https://apps.apple.com/de/app/proteus-connect/id1533941485.

[5] Würth Elektronik. Source code of Proteus Connect app for Android. https://github.com/WurthElektronik/Proteus-Connect-Android.

[6] Würth Elektronik. Source code of Proteus Connect app for iOS. https://github.com/WurthElektronik/Proteus-Connect-iOS.

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Contact:
Würth Elektronik eiSos GmbH & Co. KG
Division Wireless Connectivity & Sensors

Max-Eyth-Straße 1
74638 Waldenburg
Germany

Tel.: +49 651 99355-0
Fax.: +49 651 99355-69
www.we-online.com/wireless-connectivity