

## ANR004

PROTEUS HOW TO USE THE  
PERIPHERAL ONLY MODE

VERSION 2.5

JULY 19, 2023

**WÜRTH ELEKTRONIK** MORE THAN YOU EXPECT

## Revision history

Manual version	Notes	Date
1.0	<ul style="list-style-type: none"><li>Initial version</li></ul>	February 2017
1.1	<ul style="list-style-type: none"><li>Updated MTU size to 247 bytes</li></ul>	July 2017
2.0	<ul style="list-style-type: none"><li>New corporate design</li></ul>	June 2018
2.1	<ul style="list-style-type: none"><li>Updated product name from AMB2621 to Proteus-I</li></ul>	November 2018
2.2	<ul style="list-style-type: none"><li>Updated file name to new AppNote name structure. Updated important notes, legal notice &amp; license terms chapters.</li></ul>	June 2019
2.3	<ul style="list-style-type: none"><li>Added Proteus-II and Proteus-III description</li><li>Updated address of Division Wireless Connectivity &amp; Sensors location</li></ul>	January 2020
2.4	<ul style="list-style-type: none"><li>Restructured app note</li><li>Added new chapter Quickstart with new connection setup examples</li><li>Added information on the Proteus-III mini evaluation board</li></ul>	February 2021
2.5	<ul style="list-style-type: none"><li>Updated Important notes, meta data and document style</li></ul>	July 2023

## Abbreviations

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.
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.
LSB	Least significant bit	
MAC		MAC address of the module.
MSB	Most significant bit	
MTU	Maximum transmission unit	Maximum packet size of the Bluetooth® connection.
Payload		The intended message in a frame / package.
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.
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 is a Bluetooth® module based on the nRF52 Nordic Semiconductors SoC which provides various Bluetooth® LE and low power features.

In addition to the standard command mode, that uses predefined commands to run and configure the radio module, Würth Elektronik eiSos launches the "peripheral only mode" on the Proteus to use the module as Bluetooth® LE bridge in a simple way.

In this mode, a Bluetooth® LE interface using the static passkey authentication method (with bonding) and a transparent UART interface is provided, such that no configuration of the module is required to equip a custom application with it.

In case the user needs a non-standard configuration, it can be configured in advance using the command mode, or upon request Würth Elektronik eiSos can apply customer specific configurations during the production process.

The following chapters describe how to set the module into peripheral only mode and which steps have to be applied to establish a connection to the radio module.

## 2 Prerequisites

- A Proteus evaluation board in factory state, for example
  - the Proteus-I evaluation board with firmware version 3.0.0 or newer.
  - the Proteus-II evaluation board.
  - the Proteus-III evaluation board or mini evaluation board.
- A central device, that initiates the connection setup. For example
  - a smart phone with Bluetooth® LE function and the Nordic Semiconductor nRF Connect App.
  - another Proteus evaluation board or mini evaluation board.
  - a Proteus USB radio stick.

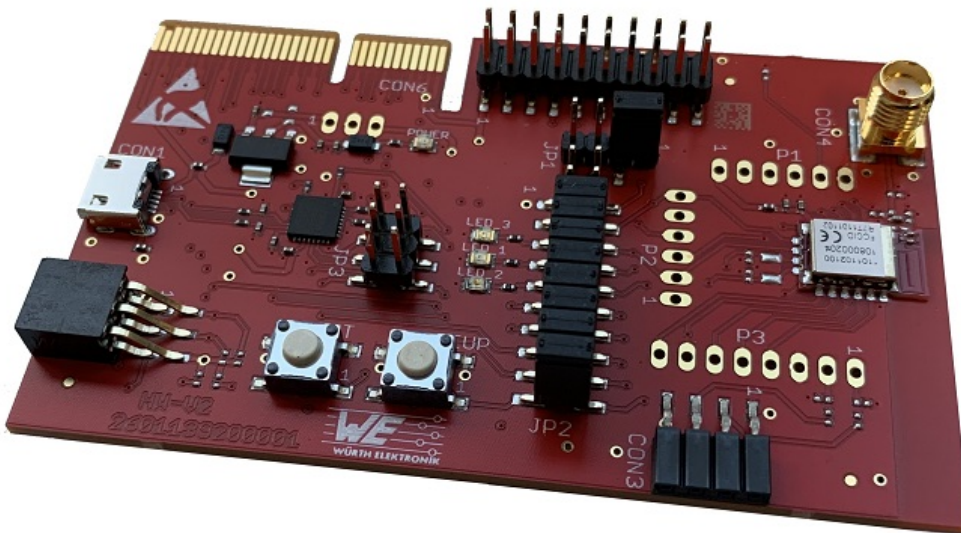


Figure 1: Proteus-III evaluation board



To be sure that the Proteus radio module or Proteus USB radio stick is in factory state, please run a factory reset before doing any other action.



Please check whether the most recent firmware is installed on any Proteus radio module, EV board or Proteus USB radio stick.

### 3 Peripheral only mode: General information

For a better understanding of the content of this chapter, basic knowledge of the Bluetooth® standard as well as that of the SPP-like profile is of advantage. Please find more details on that in the respective advanced developer guide:

- ANR002 Proteus-I advanced developer guide [1]
- ANR005 Proteus-II advanced developer guide [2]
- ANR009 Proteus-III advanced developer guide [3]

#### 3.1 How to set the Proteus radio module to peripheral only mode?

The Proteus starts in peripheral only mode, when a HIGH level is applied at the *OPERATION\_MODE* pin and a reset is done via the */RESET* pin. If the *OPERATION\_MODE* pin is LOW during the reset, the module starts in normal operation mode with command interface.



A pull-down is applied to the *OPERATION\_MODE* pin during start-up. Thus increased currents can occur for a period  $\leq 1$  ms.



After the start-up procedure has been finished, the *OPERATION\_MODE* pin and thus the applied signal level has no function.



For Proteus-III, the *OPERATION\_MODE* pin has been renamed to *MODE\_1*, while maintaining the same function. Throughout this app note we will use *OPERATION\_MODE* as a term for this pin.

In case of the evaluation board for Proteus, simply connect the *OPERATION\_MODE* pin to *VCC* by setting the respective jumper (see figure 2, 3 and 4). Then press the reset button to start the module in peripheral only mode.

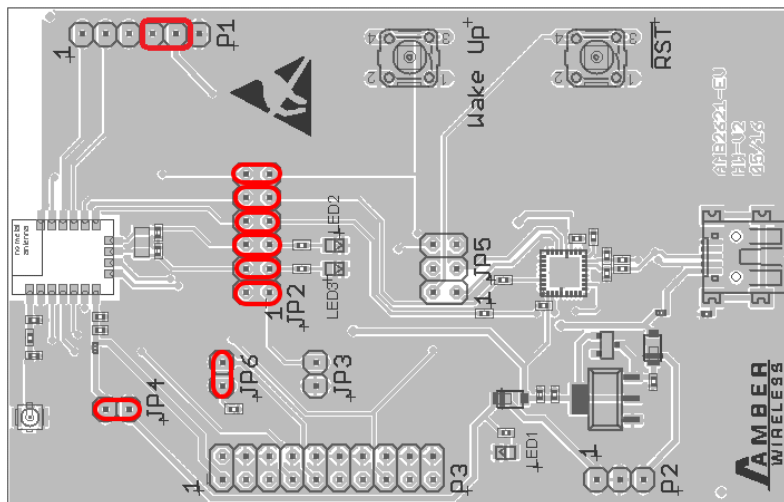


Figure 2: On Proteus-I and Proteus-II evaluation board, set these jumpers to start the peripheral only mode after reset.

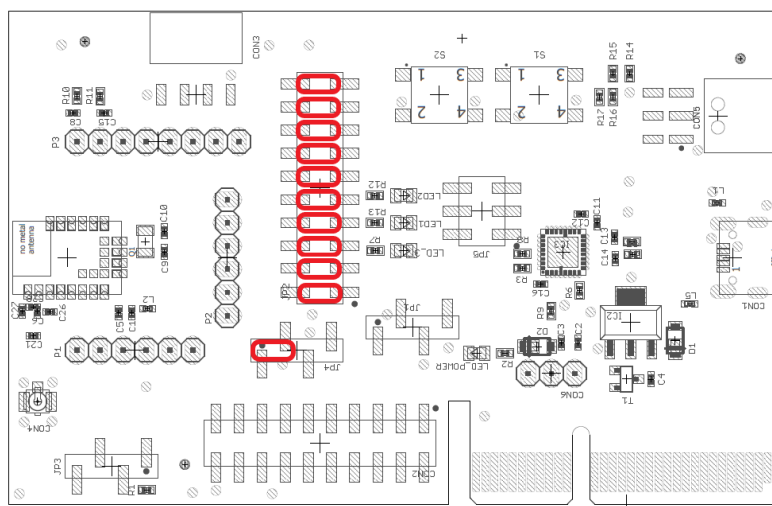


Figure 3: On Proteus-III evaluation board, set these jumpers to start the peripheral only mode after reset.



## ANR004 - Proteus How to use the peripheral only mode

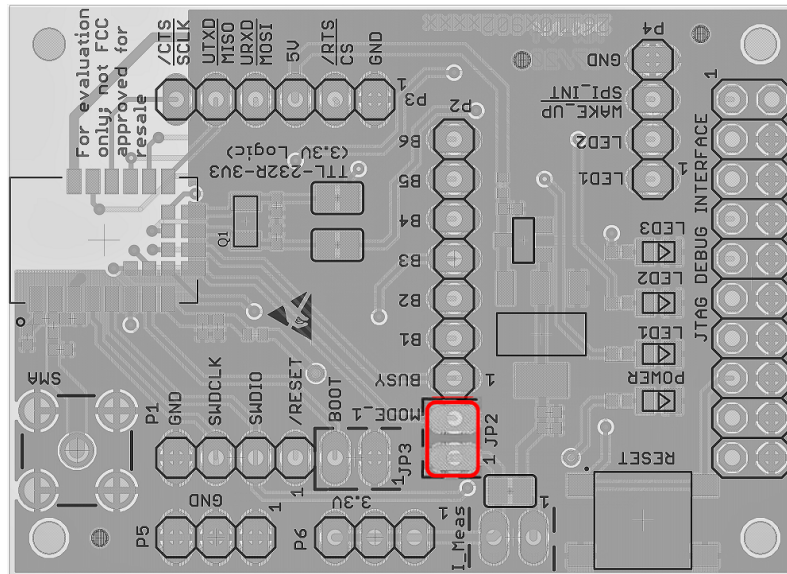


Figure 4: On Proteus-III mini evaluation board, set these jumpers to start the peripheral only mode after reset.

## 3.2 General connection setup information

In factory state, the peripheral only mode uses the static passkey pairing with bonding authentication method, which requests a static passkey from the connecting device. Figure 5 shows the steps that have to be performed successively during connection setup using the static passkey pairing method:

1. Physical connection establishment

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

2. Pairing process

The authentication and exchange of encryption information is part of the pairing process. The central device must request at least the same security level to access the characteristics of the Proteus. The peripheral only mode uses static passkey bonding by default. The Proteus waits for the bonding request of the central device to perform this step.



In case the central device goes on with the next steps without placing this bonding request, the peripheral device disconnects immediately as the required security level is not achieved. The same holds, if the central device places a bonding request with lower security level than required by the peripheral device (static passkey with bonding).

3. Exchange of the maximum transmission unit (MTU)

The maximum transmission unit can be increased to allow the transmission of larger data packets. The Proteus 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® LE 4.0 default MTU which results in 19 bytes payload for the user but will be compatible to pre Bluetooth® LE 4.2 devices.

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

The characteristics offered by the Proteus have to be discovered by the central.

5. Notification enable

The peripheral must let the central know, when there is new data. Therefore, notifications have to be enabled. 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 acts as peripheral in figure 5.

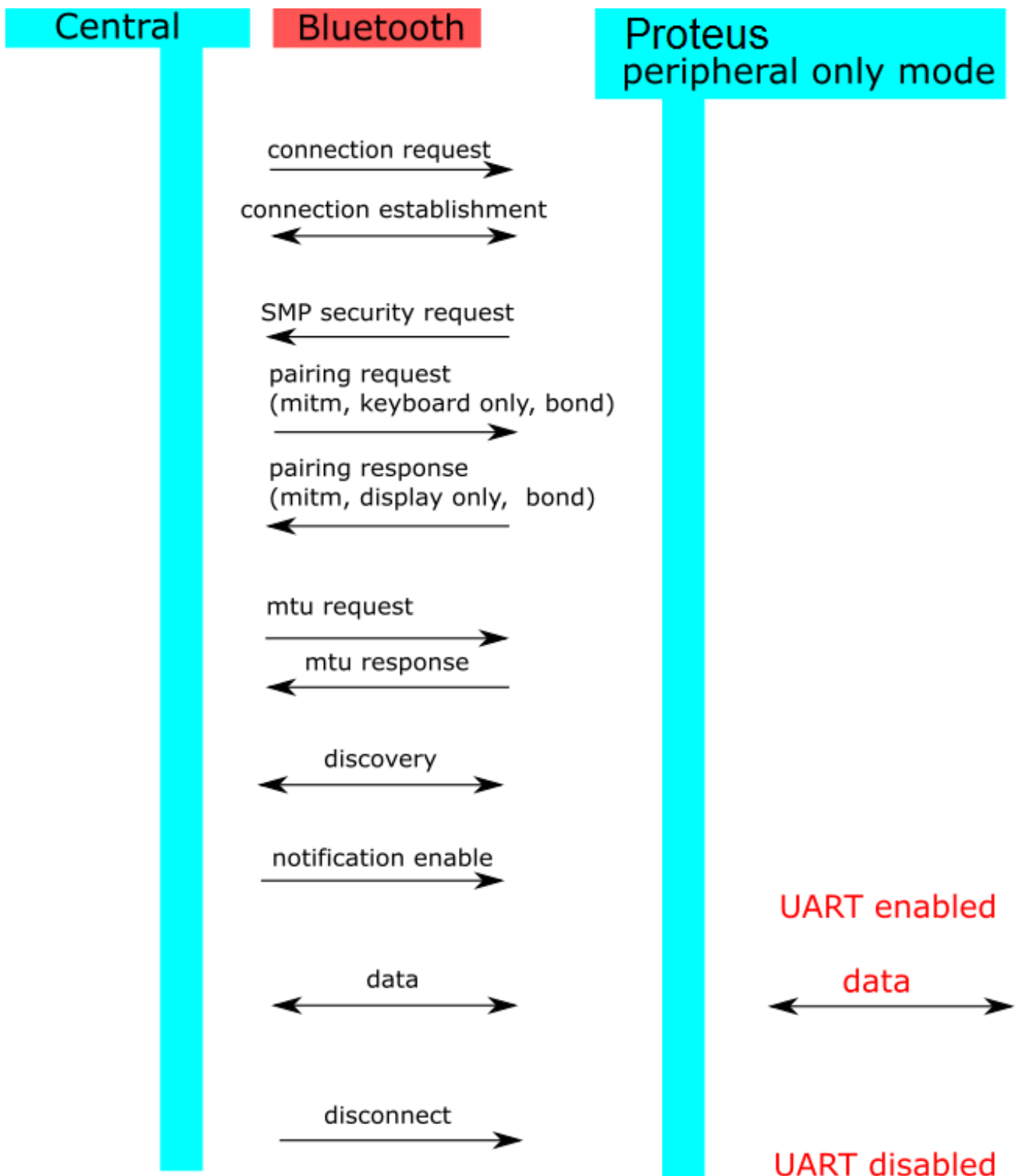


Figure 5: Steps for the connection setup in static passkey mode (default)

### 3.3 Preconfiguring of the module

In case user settings (such as UART baud rate, security mode or the static passkey value) have to be modified, please start the module in normal mode (apply a low signal at the *OPERATION*

*MODE* pin during start-up). Then use the commands like `CMD_SET_REQ` to update these user settings and switch back to peripheral only mode (apply a high signal to the *OPERATION MODE* pin during start-up).



For security reasons it is strongly recommended to change the default `RF_StaticPasskey` to a customer specific passkey.



Custom product: Upon request Würth Elektronik eiSos can apply customer specific configuration(s) during the production process.

## 4 Quickstart

In chapter 3.2, it has been described which steps have to be performed by the central device to setup a connection to a Proteus radio module running in peripheral only mode. What this means in practice will be shown in this chapter. Two examples are following. First, how to use a smart phone and the nRF Connect App to setup a connection to a Proteus radio module running in peripheral only mode (see chapter 4.1). And second, how to use another Proteus radio module or Proteus USB radio stick to do so (see chapter 4.3).

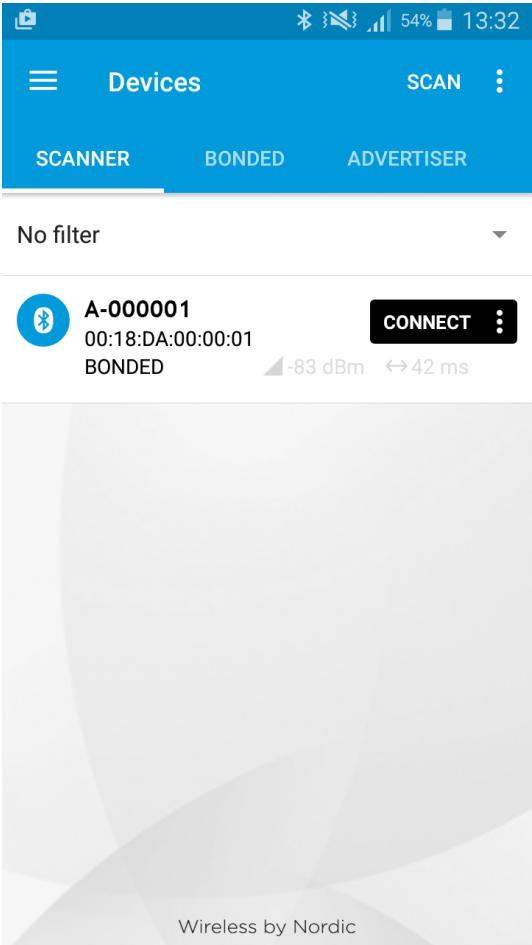
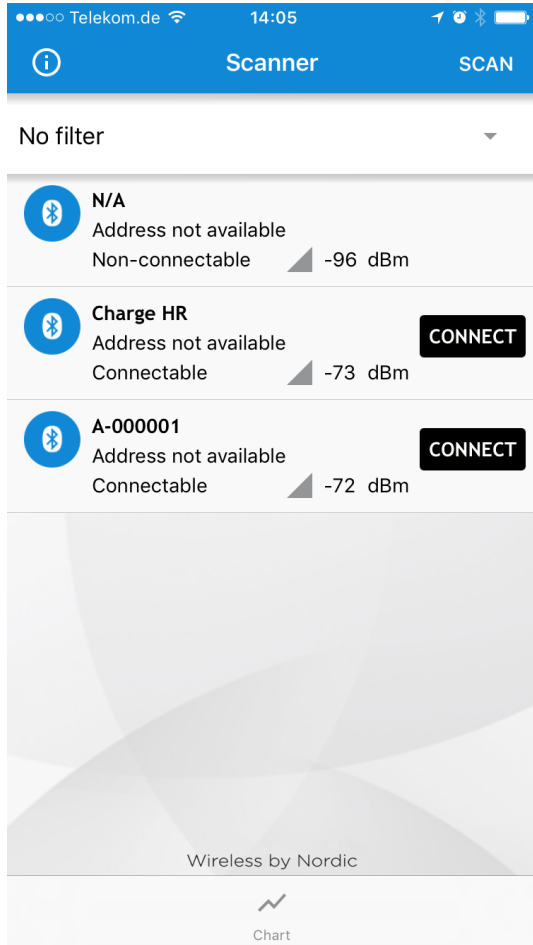
### 4.1 Smart phone using nRFConnect app as central device

This chapter describes how to setup a connection to the Proteus radio module in peripheral mode (factory state), when a smart phone and the nRF Connect App are used.



The nRF Connect App is an open source App providing standard Bluetooth® LE functions for iOS as well as for Android devices.

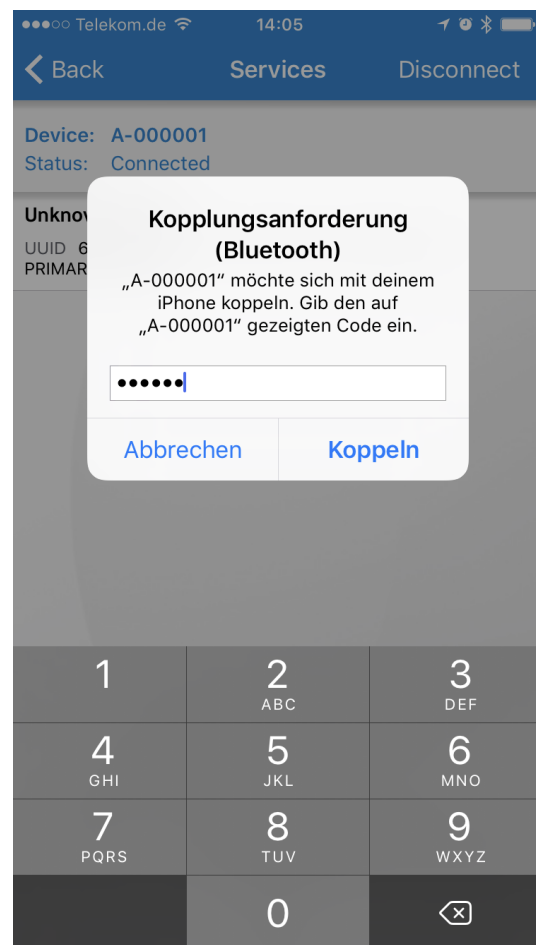
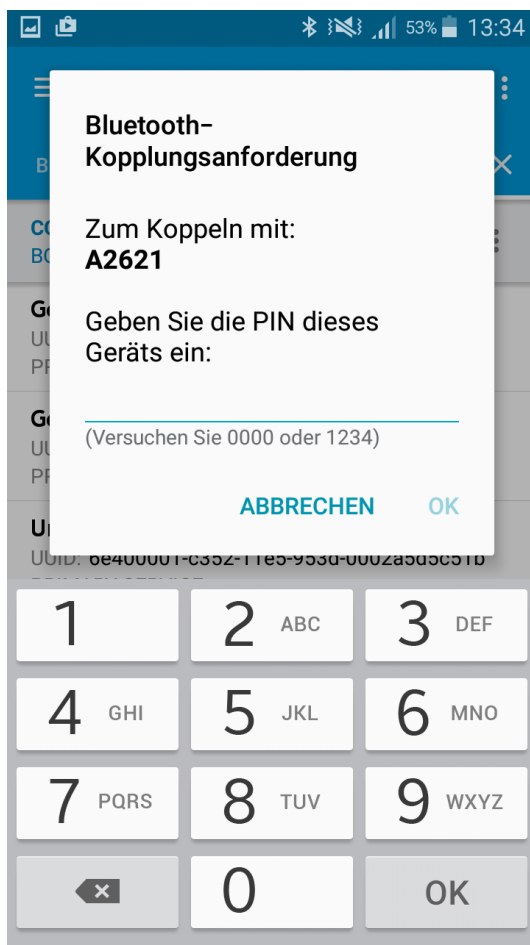
Please perform the following steps:

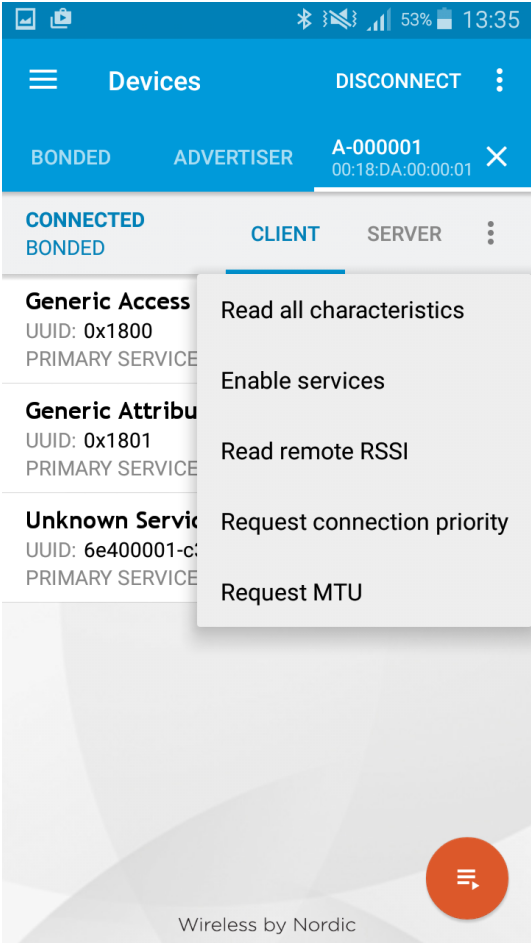
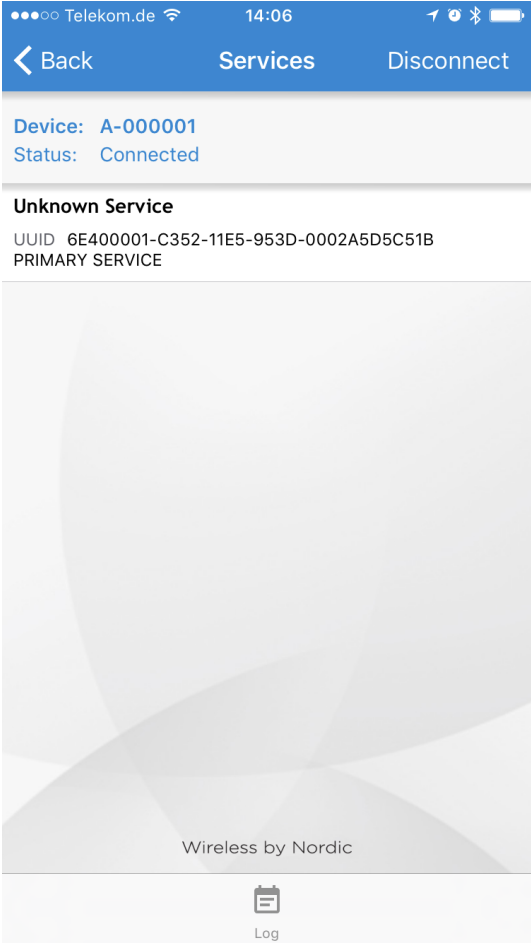
Android	iOS
<ul style="list-style-type: none"> <li>• Connect the module to a PC and open a terminal program using the Proteus default UART settings (115200 Baud, 8n1).</li> <li>• Set the module into peripheral only mode as described in chapter 3. 1. Initially, the module is advertising. Thus the Proteus <i>LED_1</i> is blinking.</li> <li>• Start your smart phone, enable the Bluetooth® LE feature and start the nRF Connect App.</li> <li>• Press "SCAN" to find the module on the radio.</li> <li>• When the module A-xxxxxx appears, press connect. (Note: the part after "A-" is the 3 LSB as ASCII hex of the BTMAC, the fixed part "0x0018DA" is not part of the device descriptor).</li> </ul>	
	

## Android

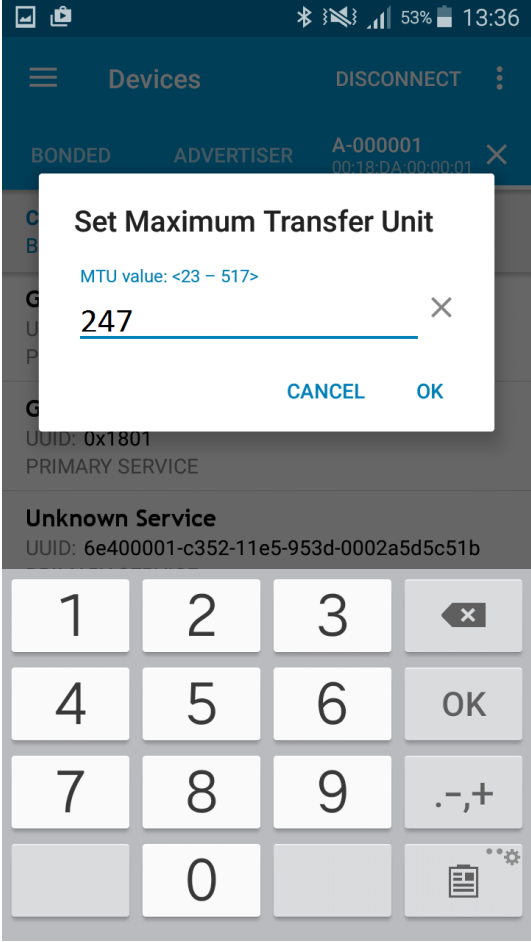
## iOS

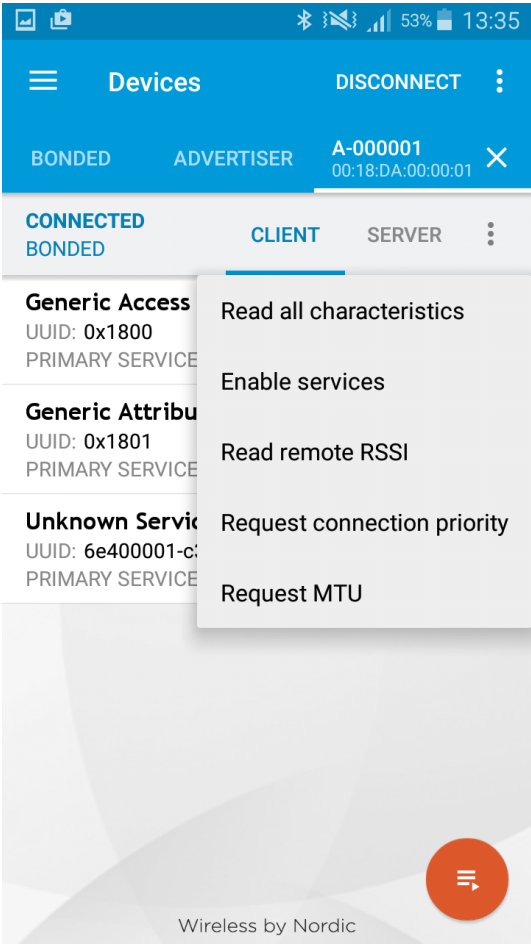
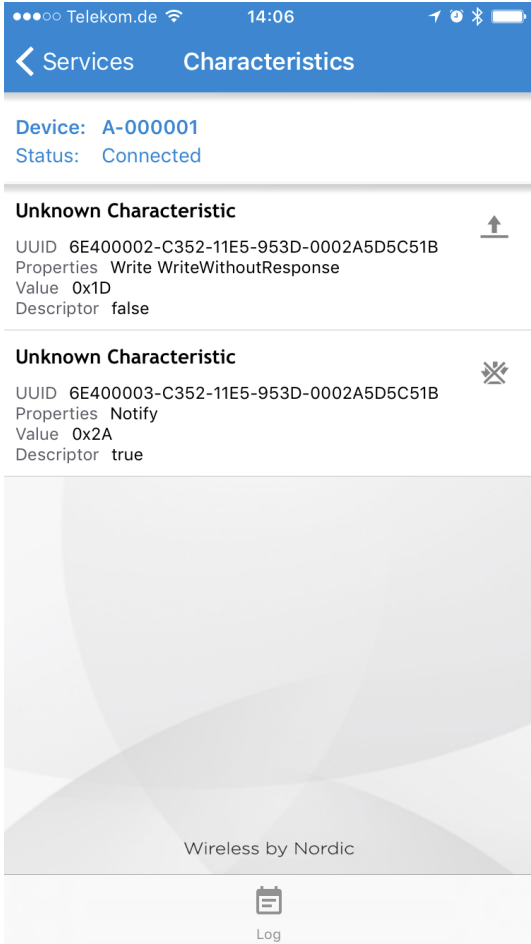
- As soon as the module has received the connection request the module *LED\_1* (*LED\_3* on the Proteus-EV) will constantly light up.
- Then the radio module requests for the static passkey. In default, the passkey is "123123".
- The Bluetooth® coupling requirement popup is shown in your smart phone.
- 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.

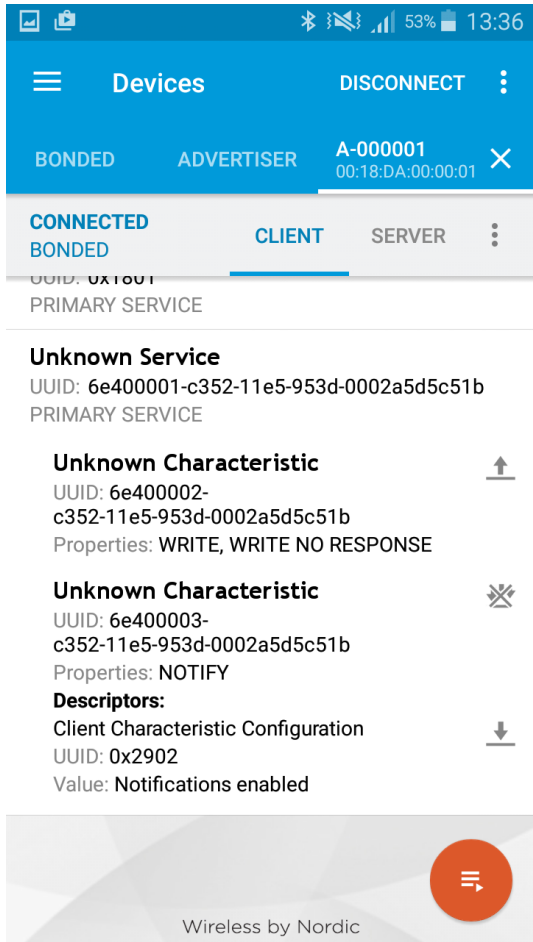
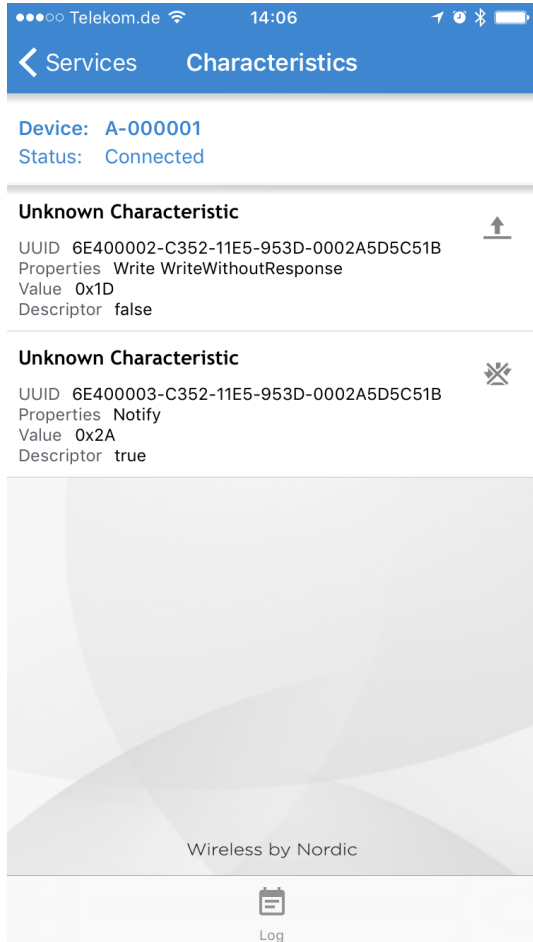


Android	iOS
<div><ul style="list-style-type: none"><li>• Now you are authenticated.</li><li>• Please click on the menu bullets on the right and press "Request MTU" to request for a larger MTU.</li></ul></div> <div></div>	<div><ul style="list-style-type: none"><li>• Now you are authenticated.</li><li>•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

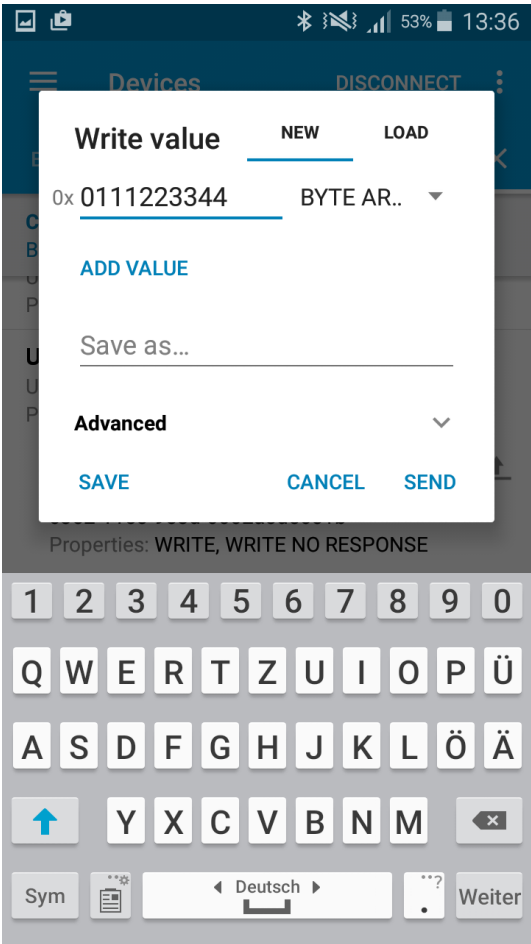
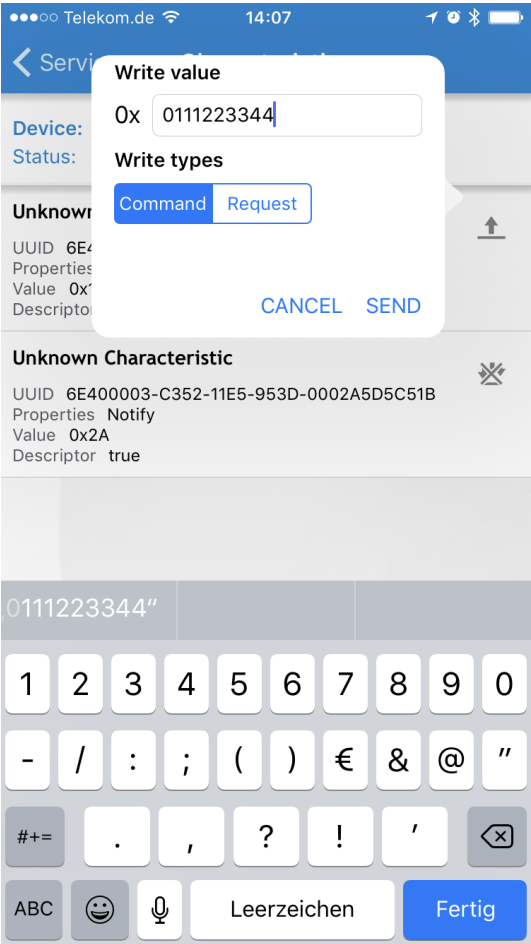


Android	iOS
<ul style="list-style-type: none"><li>The Proteus allows an MTU of up to 247 bytes, which results in a payload size of 243 bytes.</li></ul> 	<ul style="list-style-type: none"><li>The iOS App runs this step simultaneously in the background, a user-defined MTU is not possible.</li></ul>

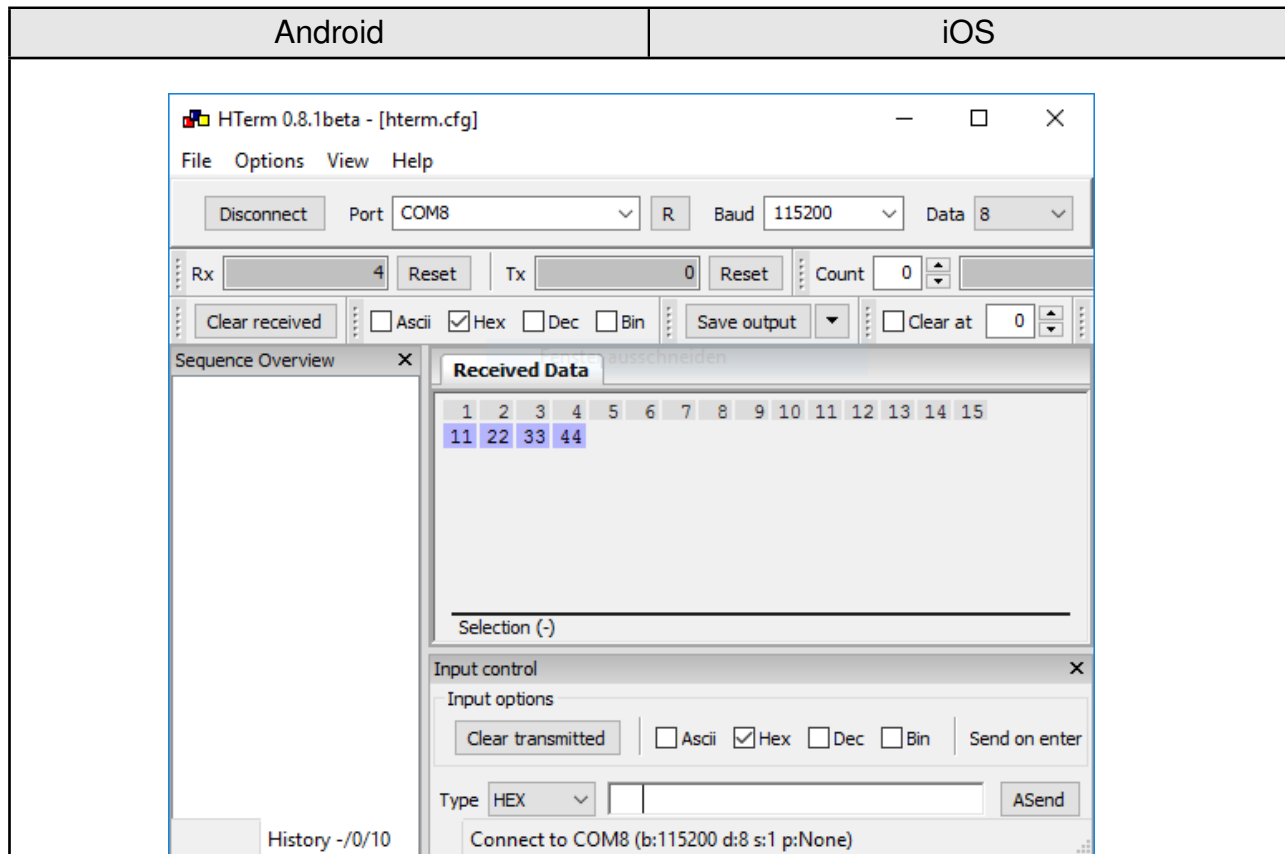
Android	iOS
<ul style="list-style-type: none"> <li>Again click on the menu bullets on the right and press "Enable services" to enable the notifications.</li> </ul> 	<ul style="list-style-type: none"> <li>Press the arrows on the RX-characteristic 6E400003- C352- 11E5- 953D -0002A5D5C51B to enable the 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.</li> </ul> 
<ul style="list-style-type: none"> <li>As soon as the module has received the notification enable request the Proteus <i>LED_2</i> (<i>LED_2</i> on the Proteus-EV) is turned on.</li> </ul>	

Android	iOS
	

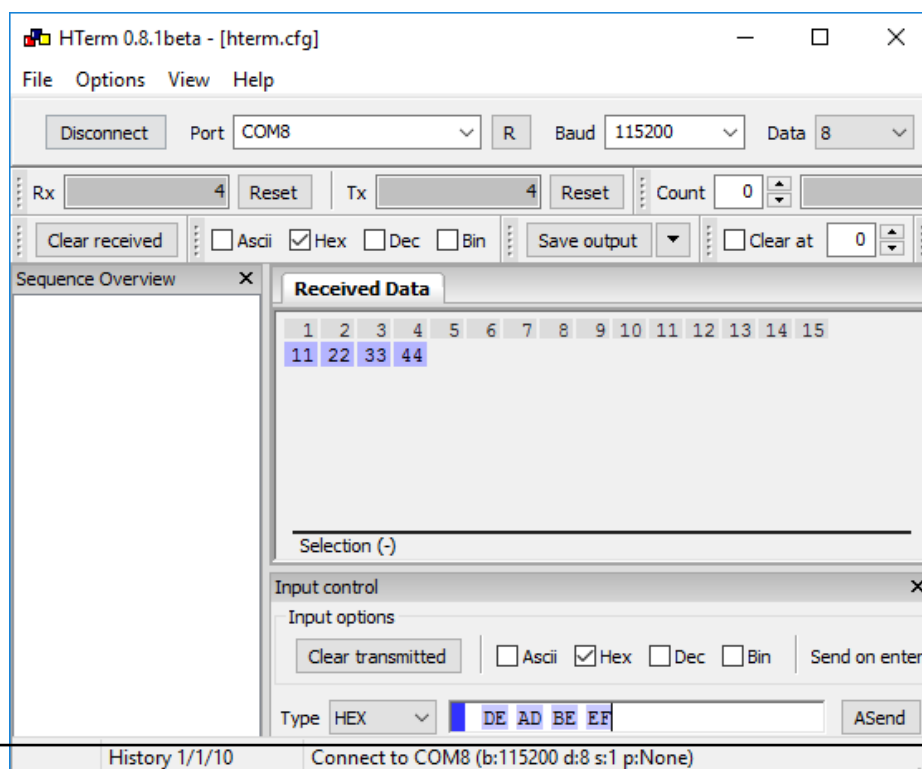
- Now you are fully connected and you can access the characteristics. The maximum size of payload depends on the chosen MTU size. Here we chose 247 bytes, which allows us to send 243 bytes of payload via the channel.
- To send data to the Proteus, press the arrow next to the TX-characteristic 6E400002-C352-11E5-953D-0002A5D5C51B.
- Then enter 0x01 as header byte followed by your payload (for example 0x11 0x22 0x33 0x44) and press "SEND". The 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 (after the 0x01 header) of 19 bytes.

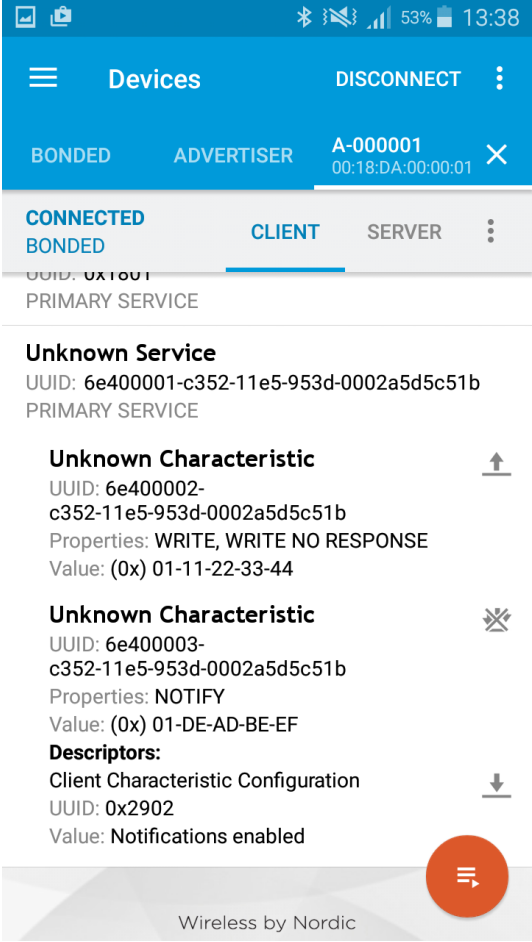
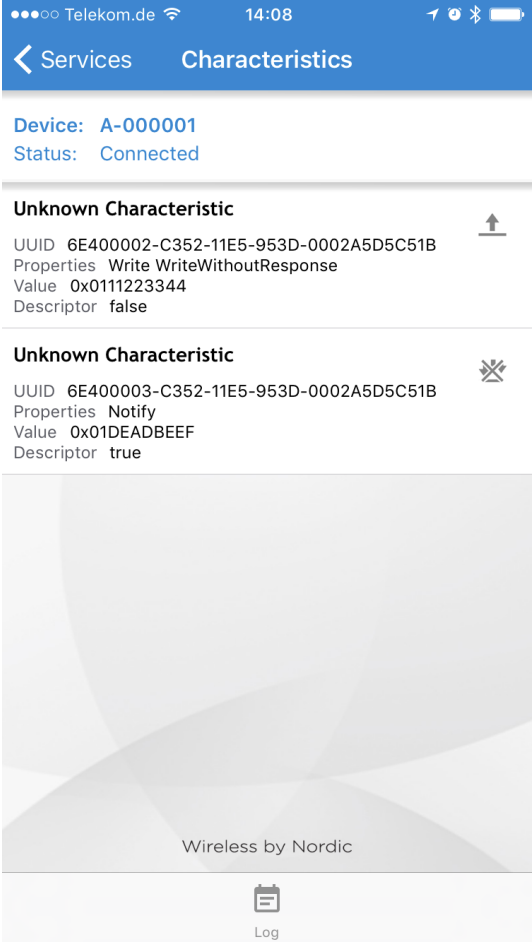
Android	iOS
	

- The payload that has been sent via radio is output by the Proteus via UART. In peripheral only mode, a transparent UART interface is used. This means, that only payload data is transmitted, without any packet header or footer. Thus the transmitted bytes 0x11 0x22 0x33 0x44 are displayed on the connected terminal program.



- To send back data simply enter your payload in the respective terminal program field and press enter. In this example we choose 0xDE 0xAD 0xBE 0xEF. The header 0x01 will be automatically applied by the module and is not to be transmitted by the host.
- Here again the maximum payload size (MTU) must be respected.



Android	iOS
<ul style="list-style-type: none"><li>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.</li></ul>	
	

## 4.2 Smart phone using Proteus Connect app as central device

This chapter describes how to setup a connection to the Proteus radio module in peripheral mode (factory state), when a smart phone and the Proteus Connect App are used.



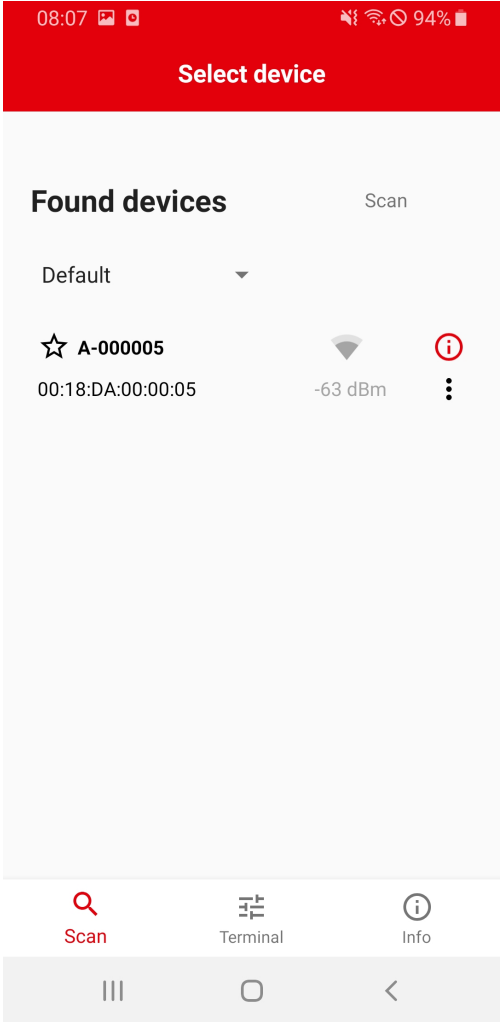
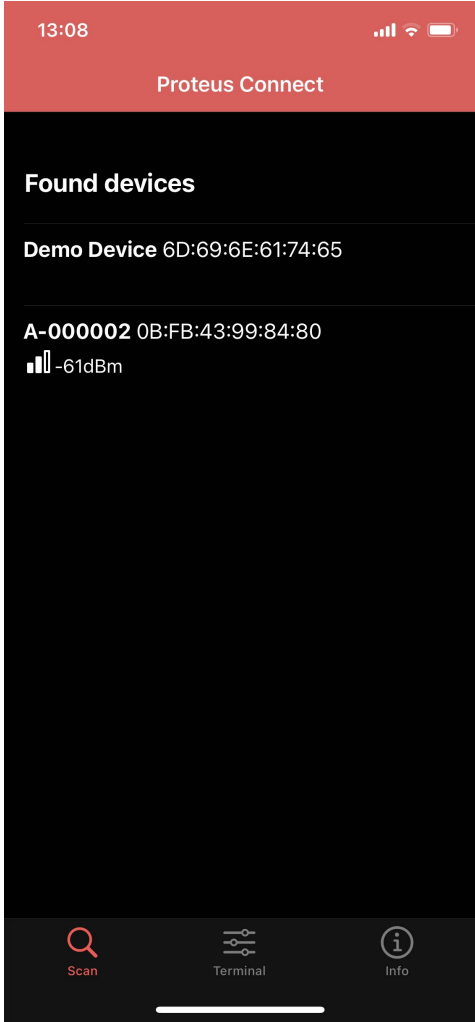
The Proteus Connect App (for iOS [5] and Android [4]) is provided by Würth Elektronik eiSos as executable as well as source code.

Please perform the following steps:

Android	iOS
<ul style="list-style-type: none"><li>• Connect the module to a PC and open a terminal program using the Proteus default UART settings (115200 Baud, 8n1).</li><li>• Set the module into peripheral only mode as described in chapter 3.1. Initially, the module is advertising. Thus the Proteus <i>LED_1</i> is blinking.</li><li>• Start your smart phone, enable the Bluetooth® LE feature and start the Proteus Connect App.</li></ul>	



Please note that Bluetooth® LE function of Android devices is only available if the location services are enabled in addition.

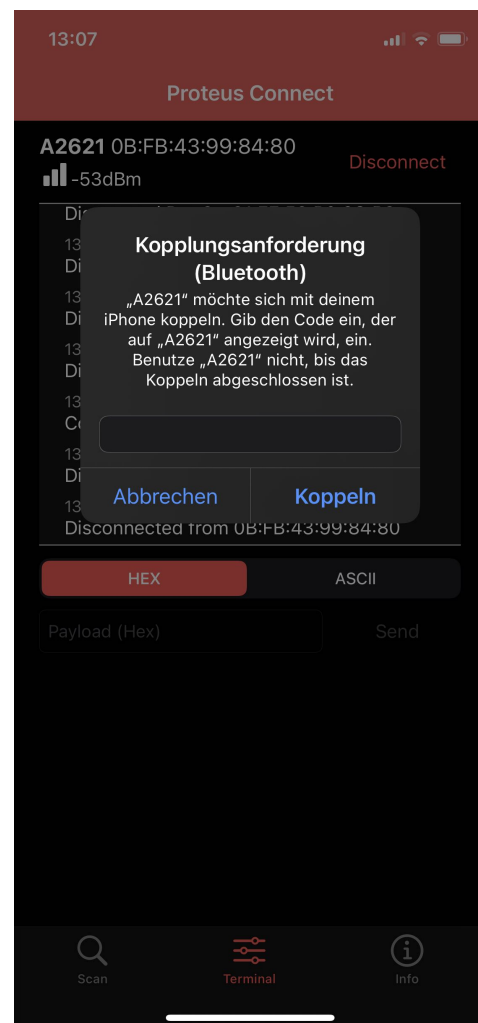
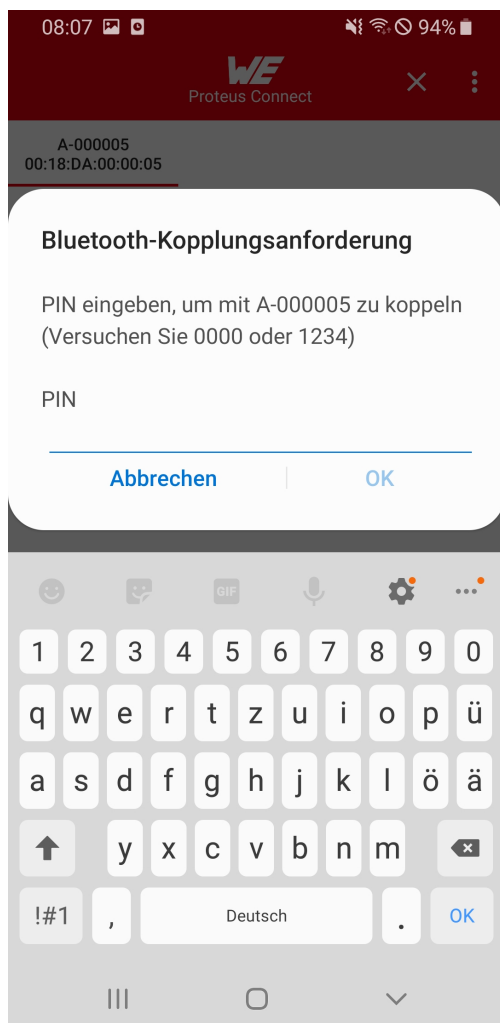
Android	iOS
<ul style="list-style-type: none"> <li>Press "Scan" to find the module on the radio.</li> </ul> 	
<ul style="list-style-type: none"> <li>When the module A-xxxxxx appears, press connect. (Note: the part after "A-" is the 3 LSB as ASCII hex of the BTMAC, the fixed part "0x0018DA" is not part of the device descriptor).</li> <li>As soon as the module has received the connection request the module <i>LED_1</i> (<i>LED_3</i> on the Proteus-EV) will constantly light up.</li> </ul>	



## Android

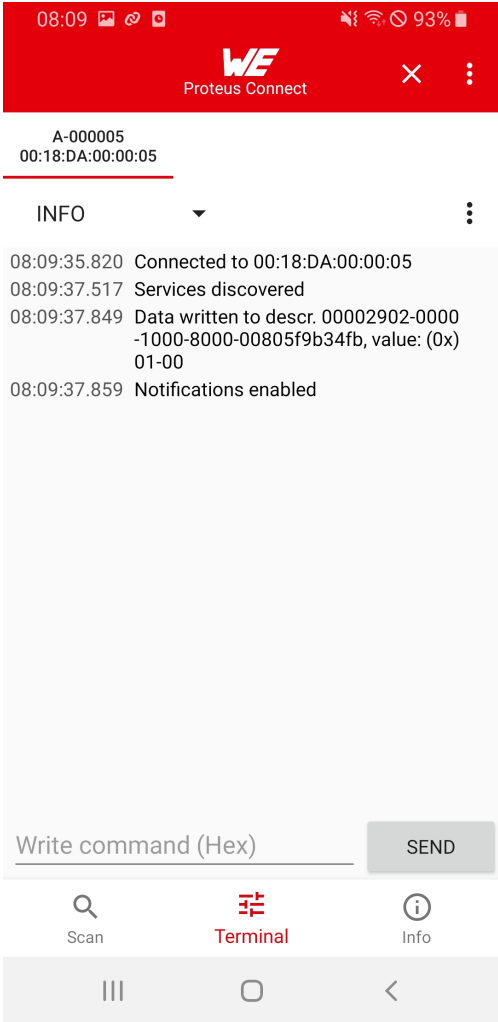
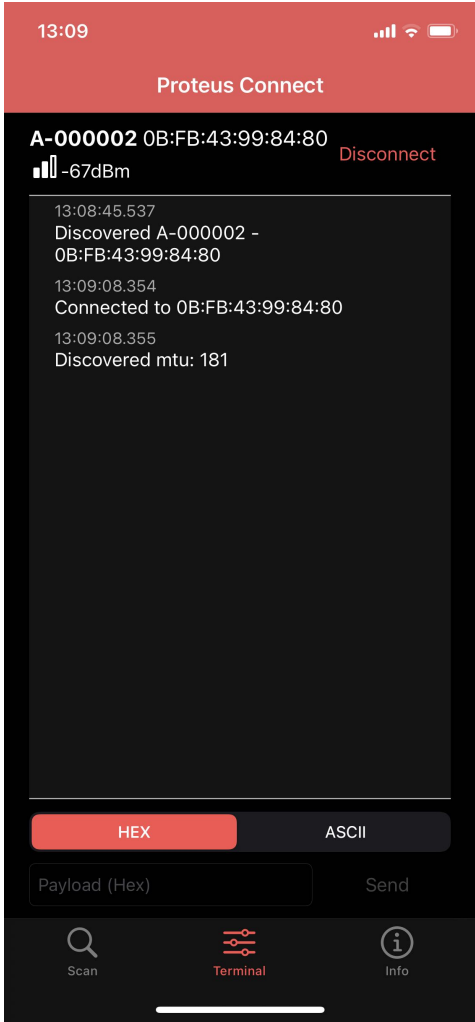
## iOS

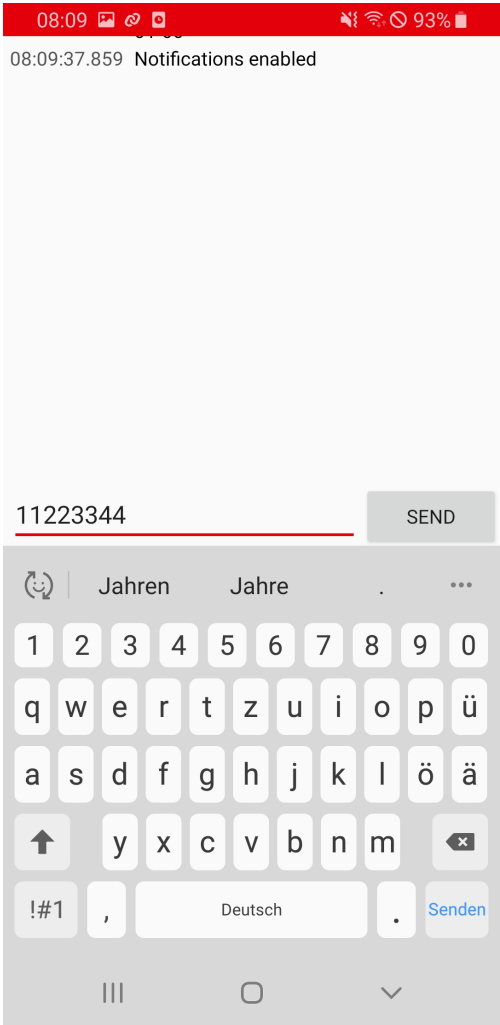
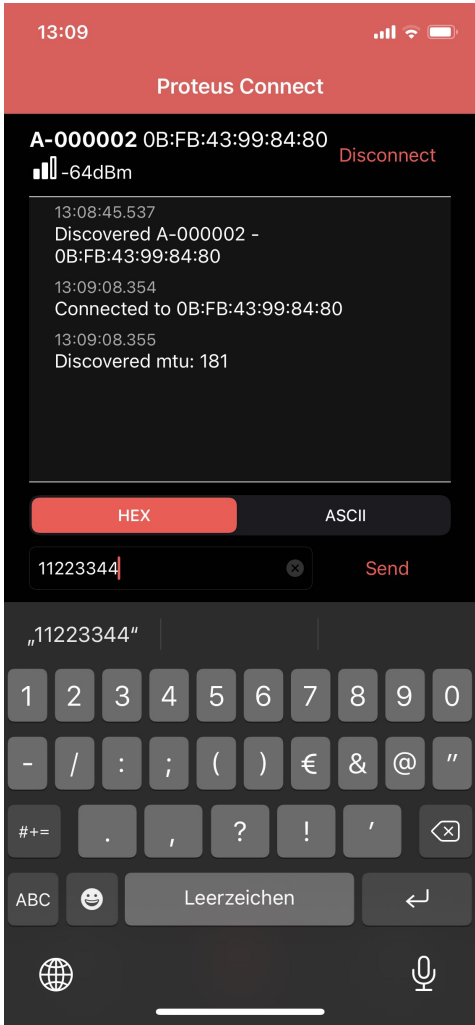
- Then the radio module requests for the static passkey. In default, the passkey is "123123".
- The Bluetooth® coupling requirement popup is shown in your smart phone.
- When the bonding feature is enabled in the authentication settings and the bonding information already exists, a re-entering of the passkey is not required when reconnecting.





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.

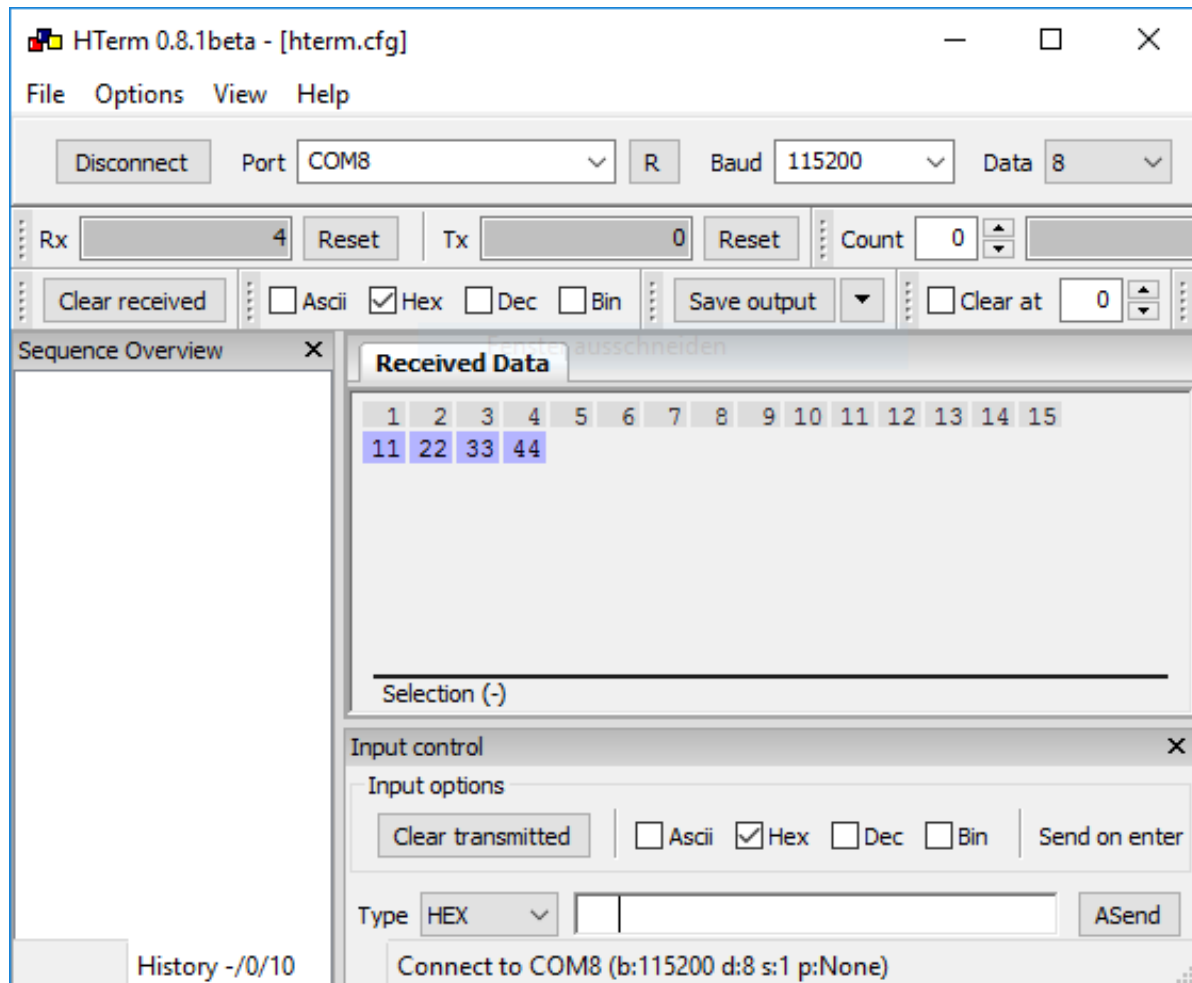
Android	iOS
<ul style="list-style-type: none"> <li>Now you are authenticated and the <i>LED_2</i> (<i>LED_2</i> on the Proteus-EV) is turned on. Now data can be transmitted in both directions.</li> </ul>	
	

Android	iOS
<ul style="list-style-type: none"> <li>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) 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.</li> <li>Android usually allows up to 243 bytes.</li> </ul> 	<ul style="list-style-type: none"> <li>iOS usually allows up to 181 bytes</li> </ul> 

## Android

## iOS

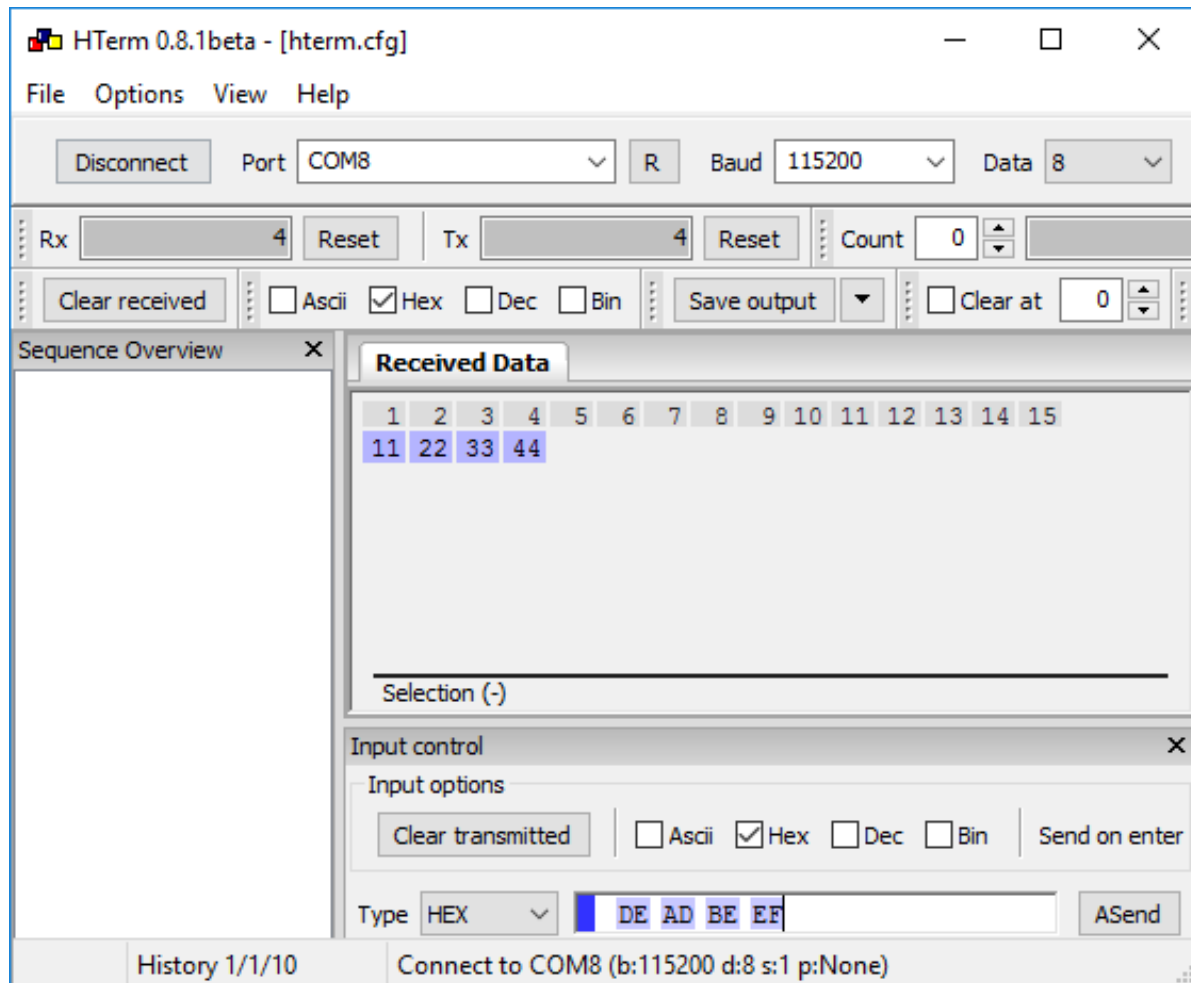
- The payload that has been sent via radio is output by the Proteus via UART. In peripheral only mode, a transparent UART interface is used. This means, that only payload data is transmitted, without any packet header or footer. Thus the transmitted bytes 0x11 0x22 0x33 0x44 are displayed on the connected terminal program.

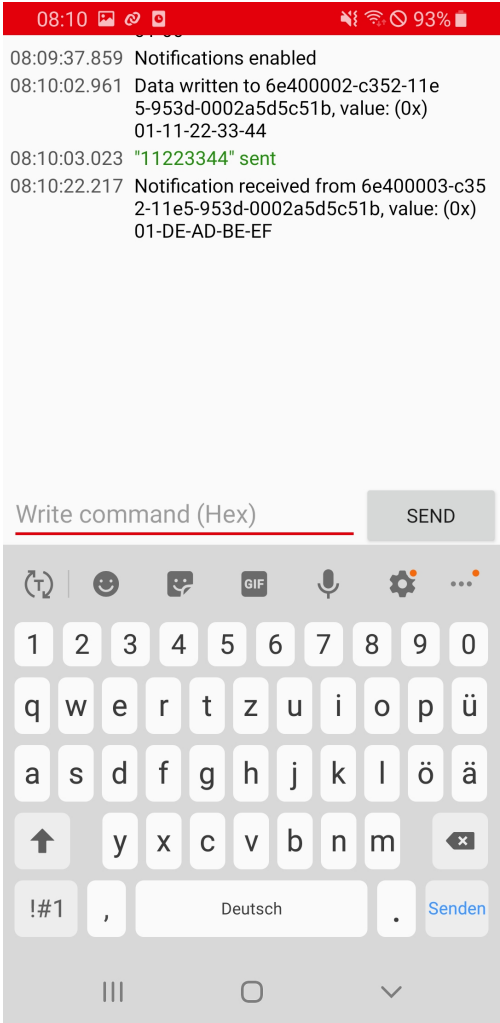
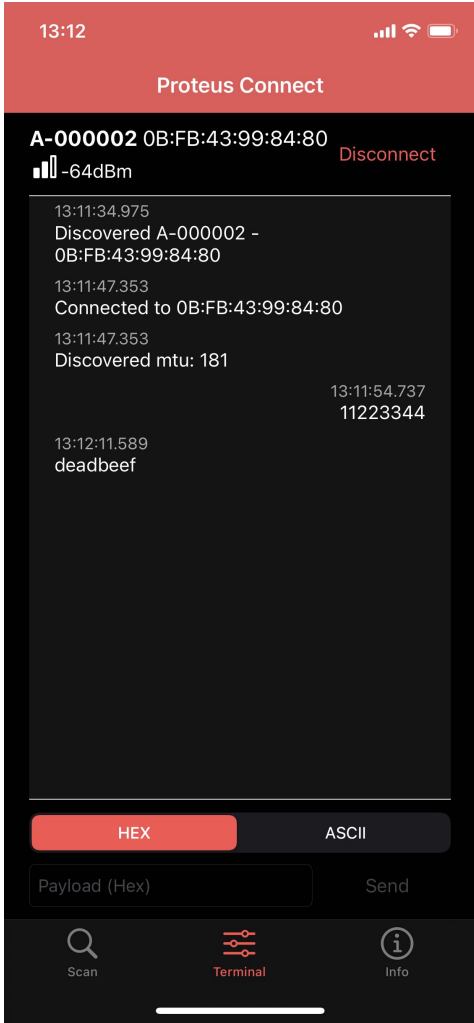


## Android

## iOS

- To send back data simply enter your payload in the respective terminal program field and press enter. In this example we choose 0xDE 0xAD 0xBE 0xEF. The header 0x01 will be automatically applied by the module and is not to be transmitted by the host.
- Here again the maximum payload size (MTU) must be respected.



Android	iOS
<ul style="list-style-type: none"><li>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.</li></ul> 	<ul style="list-style-type: none"><li>The received data is shown in the status window.</li></ul> 

### 4.2.1 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.

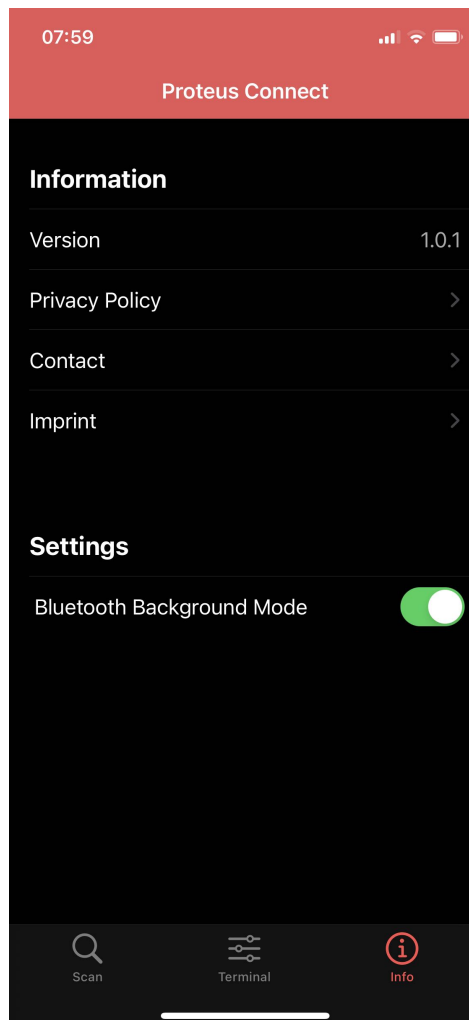


Figure 6: Enable the background service on iOS

### 4.3 Proteus module or USB radio stick as central device

This chapter describes how to setup a connection to the Proteus radio module in peripheral mode (factory state), when another Proteus radio module or even Proteus USB radio stick is used as central device.



For reasons of simplicity, we will call the Proteus radio module or USB radio stick, that is intended to setup the connection to the Proteus module running in peripheral only mode, **Proteus\_central**. Furthermore, we will call the Proteus module running in peripheral only mode, **Proteus\_peripheral**.



Please note that the **Proteus\_central** must run in command mode to initiate the connection setup.



In this example we assume that the MAC of the **Proteus\_peripheral** is 0x0018DA000011.

#### 1. Configuring the correct security mode of the **Proteus\_central**:

The **Proteus\_peripheral** uses the "static passkey pairing with bonding" as default security mode. As the central device must use the same security mode, the user setting `RF_SecFlags` of the **Proteus\_central** must be also set to "static passkey with bonding" (0x0B = 11), before a connection setup can be done. To do so, please send the following command (`CMD_SET_REQ` with settings index 0x0C and value 0x0B) to the **Proteus\_central**:

Info	<b>Proteus_central</b>	<b>Proteus_peripheral</b>
⇒ Request <code>CMD_SET_REQ</code> to set the right security mode of the <b>Proteus_central</b>	02 11 02 00 0C 0B 16	
⇐ Response <code>CMD_SET_CNF</code> : Setting successfully set	02 51 01 00 00 52	
⇐ Response <code>CMD_GETSTATE_CNF</code> : <b>Proteus_central</b> restarted	02 41 02 00 01 01 41	

Now, the connection setup can be initiated.

#### 2. Connect **Proteus\_central** to the **Proteus\_peripheral** via Bluetooth® LE.



Info	Proteus_central	Proteus_peripheral
⇒ Request CMD_CONNECT_REQ with FS_BTMAC of <b>Proteus_peripheral</b>	02 06 06 00 11 00 00 DA 18 00 D1	
⇐ Response CMD_CONNECT_CNF: Request understood, try to connect now	02 46 01 00 00 45	
⇐ Indication CMD_CONNECT_IND: Physical connection established successfully to the module with FS_BTMAC 0x11 0x00 0x00 0xDA 0x18 0x00	02 86 07 00 00 11 00 00 DA 18 00 50	

- a) Option A: No bonding data available (i.e. when connecting for the first time). Pass key must be entered as soon as requested by the **Proteus\_central** by a CMD\_PASKEY\_IND message.



In case the CMD\_PASKEY\_IND message does not appear, but the Bluetooth® LE connection has been closed, the security settings of the **Proteus\_central** do not match. Please check again the user setting RF\_SecFlags of the **Proteus\_central**, as described in step 1.

Info	Proteus_central	Proteus_peripheral
⇐ Indication CMD_PASKEY_IND to ask for the pass key	02 8D 07 00 00 11 00 00 DA 18 00 5B	
⇒ Answer with the CMD_PASKEY_REQ and the correct pass key (default is "123123")	02 0D 06 00 31 32 33 31 32 33 09	
⇐ Response CMD_PASKEY_CNF: Pass key ok	02 4D 01 00 00 4E	
⇐ Indication CMD_SECURITY_IND, status 0x01 (encrypted link, bonding established), with FS_BTMAC 0x11 0x00 0x00 0xDA 0x18 0x00	02 88 07 00 01 11 00 00 DA 18 00 5F	
⇐ Indication CMD_CHANNELOPEN_RSP: Channel opened successfully to the module with FS_BTMAC 0x11 0x00 0x00 0xDA 0x18 0x00 and maximum payload size of 0xF3 (243 Bytes) per packet	02 C6 08 00 00 11 00 00 DA 18 00 F3 EC	

- b) Option B: Bonding data is already available (i.e. when reconnecting). No pass key must be entered.

Info	Proteus_central	Proteus_peripheral
⇐ Indication CMD_SECURITY_IND, status <b>0x00</b> (encrypted link, bonding data already available), with FS_BTMAC 0x11 0x00 0x00 0xDA 0x18 0x00	02 88 07 00 <b>00</b> 11 00 00 DA 18 00 5E	
⇐ Indication CMD_CHANNELOPEN_RSP: Channel opened successfully to the module with FS_BTMAC 0x11 0x00 0x00 0xDA 0x18 0x00 and maximum payload size of <b>0xF3</b> (243 Bytes) per packet	02 C6 08 00 00 11 00 00 DA 18 00 <b>F3</b> EC	

3. Now the connection is active. Thus data can be sent in each direction. Let us send a string "ABCD" from **Proteus\_peripheral** to **Proteus\_central**.



The RSSI values will be different in your tests.

Info	Proteus_central	Proteus_peripheral
⇒ Transparent send " <b>ABCD</b> " to <b>Proteus_central</b>		<b>41 42 43 44</b>
⇐ Indication CMD_DATA_IND: Received string " <b>ABCD</b> " from FS_BTMAC 0x11 0x00 0x00 0xDA 0x18 0x00 with RSSI of 0xCA (-54dBm)	02 84 0B 00 11 00 00 DA 18 00 CA <b>41</b> <b>42 43 44</b> 90	

4. Reply with "EFGH" to the **Proteus\_peripheral**.

Info	Proteus_central	Proteus_peripheral
⇒ Request CMD_DATA_REQ: Send " <b>EFGH</b> " to <b>Proteus_peripheral</b>	02 04 04 00 <b>45 46 47</b> <b>48</b> 0E	
⇐ Response CMD_DATA_CNF: Request received, send data now	02 44 01 00 00 47	
⇐ Transparent received string " <b>EFGH</b> "		<b>45 46 47 48</b>
⇐ Response CMD_TXCOMPLETE_RSP: Data transmitted successfully	02 C4 01 00 00 C7	

5. Now **Proteus\_central** closes the connection.

Info	Proteus_central	Proteus_peripheral
⇒ Request CMD_DISCONNECT_REQ: Disconnect	02 07 00 00 05	
⇐ Response CMD_DISCONNECT_CNF: Request received, disconnect now	02 47 01 00 00 44	
⇐ Indication CMD_DISCONNECT_IND: Connection closed	02 87 01 00 16 92	

## 5 References

- [1] Würth Elektronik. Application note 2 - Proteus-I advanced developer guide. <http://www.we-online.com/ANR002>.
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- [4] Würth Elektronik. Source code of Proteus Connect app for Android. <https://github.com/WurthElektronik/Proteus-Connect-Android>.
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## 6 Important notes

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