

PAN1780

Bluetooth® Low Energy Module

Application Note

Rev. 1.0



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1 About This Document

1.1 Purpose and Audience

This document answers frequently asked questions around the PAN1780 and the PAN1780 ETU. The Application Note is intended for hardware and software engineers.

1.2 Revision History

Revision	Date	Modifications/Remarks
1.0	2020-10-15	First version

1.3 Use of Symbols

Symbol	Description
	Note Indicates important information for the proper use of the product. Non-observance can lead to errors.
	Attention Indicates important notes that, if not observed, can put the product's functionality at risk.
	Tip Indicates useful information designed to facilitate working with the module.
⇒ [chapter number] [chapter title]	Cross reference Indicates cross references within the document. Example: Description of the symbols used in this document ⇒ 1.3 Use of Symbols.
✓	Requirement Indicates a requirement that must be met before the corresponding tasks can be completed.
→	Result Indicates the result of a task or the result of a series of tasks.
This font	GUI text Indicates fixed terms and text of the graphical user interface. Example: Click Save .
Menu > Menu item	Path Indicates a path, e.g. to access a dialog. Example: In the menu, select File > Setup page .

Symbol	Description
This font	File names, messages, user input Indicates file names or messages and information displayed on the screen or to be selected or entered by the user. Examples: PAN1780.c contains the actual module initialization. The message Failed to save your data is displayed. Enter the value Product 123.
Key	Key Indicates a key on the keyboard, e.g. F10 .

1.4 Related Documents

For related documents please refer to the Panasonic website ⇒ [7.2 Product Information](#).

2 Overview

The PAN1780 is based on the Nordic nRF52840 single-chip controller. For further information please visit <https://www.nordicsemi.com/Products/Low-power-short-range-wireless/nRF52840>.

The PAN1780 ETU is a development platform for the Bluetooth 5 Low Energy (LE) PAN1780.

The design and basic usage is described in the “PAN1780 Module Integration Guide”. For further information please refer to the Panasonic website ⇒ [7.2 Product Information](#).

Nordic provides a Bluetooth software development kit (nRF5 SDK). For further information please visit <https://www.nordicsemi.com/Software-and-tools/Software/nRF5-SDK/Download#infotabs>.

This document answers frequently asked questions around the PAN1780 and the PAN1780 ETU.

3 Where are the Bluetooth Device Addresses Stored?

PAN1780 is pre-programmed and comes with both a public Bluetooth Device Address and a random Bluetooth Device Address, which can be easily used depending on the device's use-case.

All applications from the Nordic SDK automatically use the built-in random Bluetooth Device Address and must be modified when the public Bluetooth Device Address shall be used.

During development, access to these addresses is only possible using nRF Command Line Tools.

3.1 Overview

The Bluetooth Core Specification specifies that all Bluetooth devices shall have a Bluetooth Device Address that uniquely identifies the device to another Bluetooth device¹.

Each Bluetooth device shall either be allocated a unique 48-bit public Device Address. The Device Address shall be a 48-bit extended unique identifier (EUI-48) created in accordance with the IEEE 802-2014 standard² in section "Universal addresses".

Alternatively, a 48-bit random Device Address may be used which must follow a few requirements and shall not change once initialized until the device is power cycled³.

PAN1780 is pre-programmed and comes with both a public and a random Device Address, which can be easily used depending on the device's use-case.

All applications from the Nordic SDK automatically use the built-in random Device Address and must be modified when the public Device Address shall be used.



Beware of accidental erase!

Special care must be taken that the pre-programmed public Device Address is not accidentally erased during usage.

For more details please refer to [⇒ 3 Where are the Bluetooth Device Addresses Stored?](#).

¹ Bluetooth Specification Version 5.0|Vol 3, Part C, 15.1 Bluetooth Device Address

² Bluetooth Specification Version 5.0|Vol 2, Part B, 1.2 Bluetooth Device Addressing

³ Bluetooth Specification Version 5.0|Vol 6, Part B, 1.3.2.1 Static Device Address

3.2 Preparations

The nRF Command Line Tools are used for development, programming, and debugging.

1. Visit the website <https://www.nordicsemi.com/>.
2. Navigate to **Software and tools** (1) > **Development tools** (2) > **Test and evaluation software** (3).

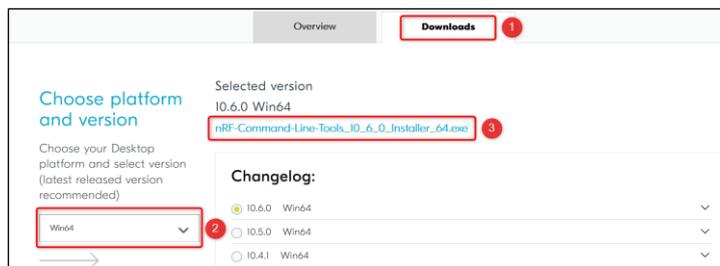


→ The detail page will be shown.

3. Scroll down to the section “nRF Command Line Tools” and click **Read more**.



4. Click on the tab **Downloads** (1), select your desired target platform (2) and click on the file link (3) to start the download.



5. Install **nRF Command Line Tools**.

3.3 Random Bluetooth Device Address

A random Device Address is available from the Factory information configuration registers (FICR).

FICRs are pre-programmed in factory and cannot be erased by the user. These registers contain chip-specific information and configuration.

The random Device Address is derived from random information that is stored in the registers `DEVICEADDR[0]` and `DEVICEADDR[1]` during production. These registers can be read out with the tool `nrfjprog.exe` from the **nRF Command Line Tools**.



The tool `nrfjprog.exe` must be executed from a command line prompt.

```
Execute nrfjprog.exe --memrd 0x100000a4 --w 8 --n 6
```

```
→ 0x100000A4: C4 F7 80 28 AB 98 |...(...|
```

The resulting random Device Address is “D8:AB:28:80:F7:C4”. First the byte order is swapped in memory. Also the two top-most bits must be both “1” according to the Bluetooth Core Specification⁴, so “0x98” becomes “0xc4”⁵ in the address the device will be using.

All applications from the Nordic SDK automatically use the built-in random Device Address. Certain applications like the secure bootloader additionally modify the random Device Address in order to implement additional features.⁶

3.4 Public Bluetooth Device Address

A public Device Address is available in the User information configuration registers (UICRs). UICRs are non-volatile memory (NVM) registers for configuring user-specific settings and can be freely modified by the user.

The public Device Address is stored in the registers `CUSTOMER[0]` and `CUSTOMER[1]` during production. These registers can be read out with the tool `nrfjprog.exe`.

```
Execute nrfjprog.exe --memrd 0x10001080 --w 8 --n 6
```

```
→ 0x10001080: CC BB AA 43 13 00 |...C...|
```

The resulting public Device Address is “00:13:43:AA:BB:CC” because the byte order is swapped. Additionally the hardware revision of PAN1780 is stored in the register `CUSTOMER[1]`.

⁴ Bluetooth Specification Version 5.0|Vol 6, Part B, 1.3.2.1 Static Device Address

⁵ <https://devzone.nordicsemi.com/f/nordic-q-a/2112/how-to-get-6-byte-mac-address-at-nrf51822/9000#9000>

⁶ <https://devzone.nordicsemi.com/f/nordic-q-a/6900/dfu-device-address-changes/24328#24328>

```
Execute nrfjprog.exe --memrd 0x10001086 --w 8 --n 2
→ 0x10001086: 03 01 |).|
```

The resulting hardware revision is “0x0103”, because the byte order is swapped.

The applications from the Nordic SDK do not use the built-in public Device Address by default. They must be modified and use the SDK function call `sd_ble_gap_address_set()` to explicitly set the Device Address after each start.⁷

3.5 Public Bluetooth Device Address Recovery

The public Device Address is stored in the non-volatile registers CUSTOMER[0] and CUSTOMER[1] of the UICRs. The UICRs can be modified or accidentally erased by the user.

If the public Device Address of PAN1780 get lost, it can be recovered in theory.

The public Device Address is encoded in the 2D barcode on the metal shield box on the PAN1780. The 2D barcode can be read out with a suitable barcode reader, which should provide a string representation of the barcode that should look like this:

```
XXXXXXXX;43AABBCC;XXXXXXXX;03;01
```

All bytes marked as “X” are “don’t care”. The resulting public Device Address is `00:13:43:AA:BB:CC` because the prefix “00:13” is not encoded. The hardware revision is “0x0103”.



Any memory in the UICRs can only be written once!

It is not possible to modify an already written public Device Address without erasing the complete UICR area before. This may have unwanted side effects.

Using the tool `nrfjprog.exe` this information can also be written back to the registers CUSTOMER[0] and CUSTOMER[1] and of the UICR:

```
Execute nrfjprog.exe --memwr 0x10001080 --val 0x43aabbcc
→ Parsing parameters.
Writing.
```

```
Execute nrfjprog.exe --memwr 0x10001084 --val 0x01030013
→ Parsing parameters.
Writing.
```

First the lower four bytes of the public Device Address are written and then the hardware revision and the remaining two bytes of the public address are written.

⁷ <https://devzone.nordicsemi.com/f/nordic-q-a/10354/change-ieee-mac-address-of-nrf51822/38423#38423>

4 How to update a Firmware Over-the-Air (OTA)

The Nordic SDK includes all the necessary building blocks to create a product that supports to perform a Device Firmware Update (DFU) via Bluetooth over-the-air.

The product must be designed in such a way that it includes not only the actual application, but for example also a bootloader. The bootloader includes the necessary functionality to perform an update. For more information please visit

https://infocenter.nordicsemi.com/index.jsp?topic=%2Fsdk_nrf5_v16.0.0%2Fexamples_bootloader.html.

If the Device Firmware Update over-the-air should work with PAN1780 correctly: Without much additional work Nordic SDK already includes the necessary precompiled binaries to perform such a demonstration. The only additional requirement is a mobile device that acts as a counterpart and serves the Device Firmware Update for the product.

4.1 Preparations

The following requirements must be met:

- ✓ “nRF Connect for Desktop” is installed on PC as explained in “PAN1780 Module Integration Guide” (“Nordic nRF Connect”).
- ✓ “nRF Connect for Mobile” is installed on a mobile device as explained in “PAN1780 Module Integration Guide” (“Mobile Apps”).
- ✓ Nordic SDK must be available at a convenient location as explained in “PAN1780 Module Integration Guide” (“Nordic SDK”).

1. Copy the file `examples\dfu\secure_dfu_test_images\ble\nrf52840\Åhrs_application_s140.zip` to the directory **Download** on the mobile device for later use.
2. Flash the pre compiled binary `examples\dfu\secure_dfu_test_images\ble\Ånrf52840\sd_s140_bootloader_buttonless_with_setting_page_dfu_Åsecure_ble_debug_without_bonds.hex` onto the PAN1780 evaluation board as explained in “PAN1780 Module Integration Guide” (“nRF Connect for Desktop”).
3. Press the reset button “LED1” to reboot the PAN1780 evaluation board.
 - The evaluation board blinks.

4.2 Update Procedure

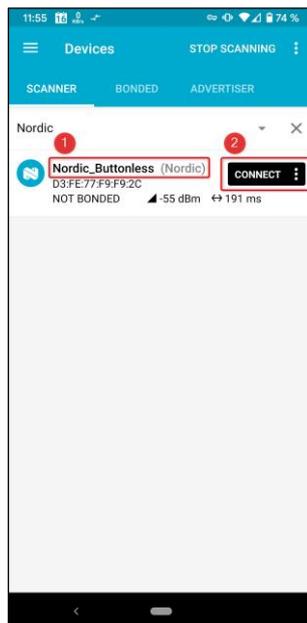
The initial application (that was programmed to the PAN1780 evaluation board) only contains a basic Bluetooth LE application. It only includes the “Secure DFU” service which can be used to initiate a Device Firmware Update.

Using this service, the device is updated and the application is replaced with a new application that includes a “Heart Rate” service instead.

1. Open the mobile app **nRF Connect**.
2. Click **SCAN** to search for nearby devices.

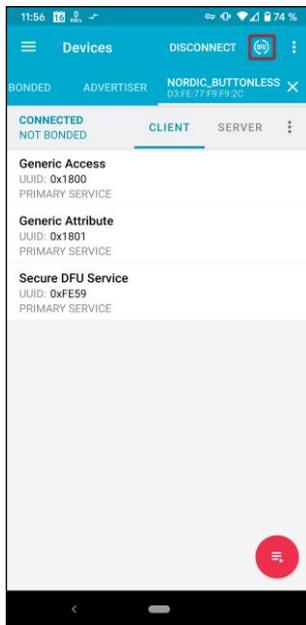


3. Look up for a device named **Nordic_Buttonless** (1).

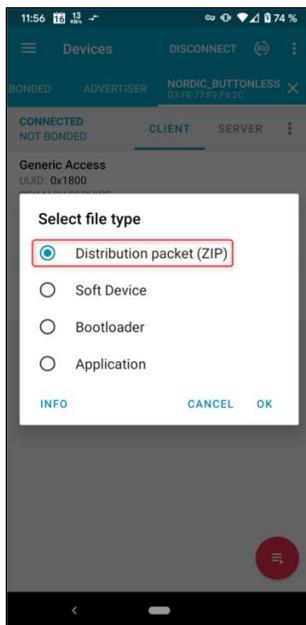


4. Click **CONNECT** (2) to establish a connection to the device.
Observe that the device does not have any additional functionality besides the “Secure DFU Service”.

5. Click the button  “DFU” to initiate the Device Firmware Update procedure.

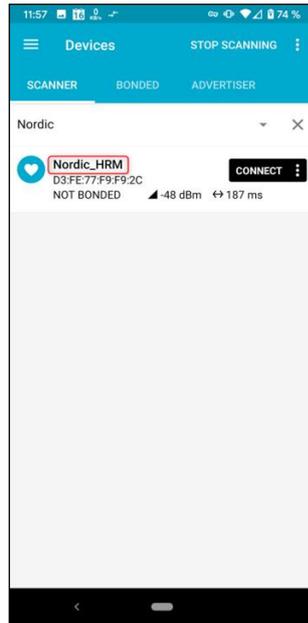


6. From the list of available options choose **Distribution packet (ZIP)**.



→ A device-specific file selector will appear.

7. Choose `hrs_application_s140.zip` (from where it was stored previously).
 - ➔ The update starts. Different mechanisms are used to visualize the progress of the update procedure (depending on the device). On some devices the progress may be visualized by a system notification.
 - ➔ After the update procedure has finished, the device name indicates that the update procedure was successful and the device is now a “Heart Rate” device instead.



5 How to Verify the Lowest Power Consumption

This chapter explains how to consistently measure the current consumption for “System OFF Mode” and “Low Power Mode” using the PAN1780 ETU.

5.1 Preparations

The PAN1780 ETU must be configured as described in the “PAN1780 Module Integration Guide” (“Getting Started”).

The following requirements must be met:

- ✓ **nRF Connect for Desktop** is installed as described in the “PAN1780 Module Integration Guide” (“Nordic nRF Connect”).
- ✓ **nRF5 SDK** is available at a convenient location as described in the “PAN1780 Module Integration Guide” (“Nordic SDK”).
- ✓ Measurement equipment for low current measurement

The measurement equipment for low current measurement must be able to measure pulsed current signals in nanoampere range and support sample periods in low μ s range.

For the following measurements the “N6705C DC Power Analyzer” from Keysight™ has been used.

5.1.1 Firmware

For power measurement purposes Nordic provides the example application **ble_app_pwr_profiling** which is included in the **nRF5 SDK** also as a precompiled binary.

For detailed information about this application please visit

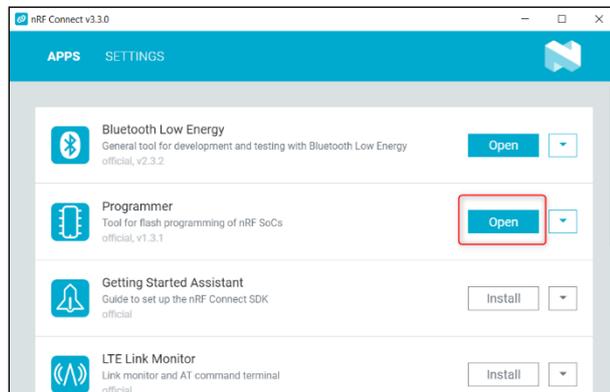
https://infocenter.nordicsemi.com/topic/sdk_nrf5_v16.0.0/ble_sdk_app_pwr_mgmt.html?cp=7_1_4_2_2_20.

The application must be flashed to the PAN1780 evaluation board using the application **nRF Connect for Desktop** as explained in “PAN1780 Module Integration Guide” (“Nordic nRF Connect”).

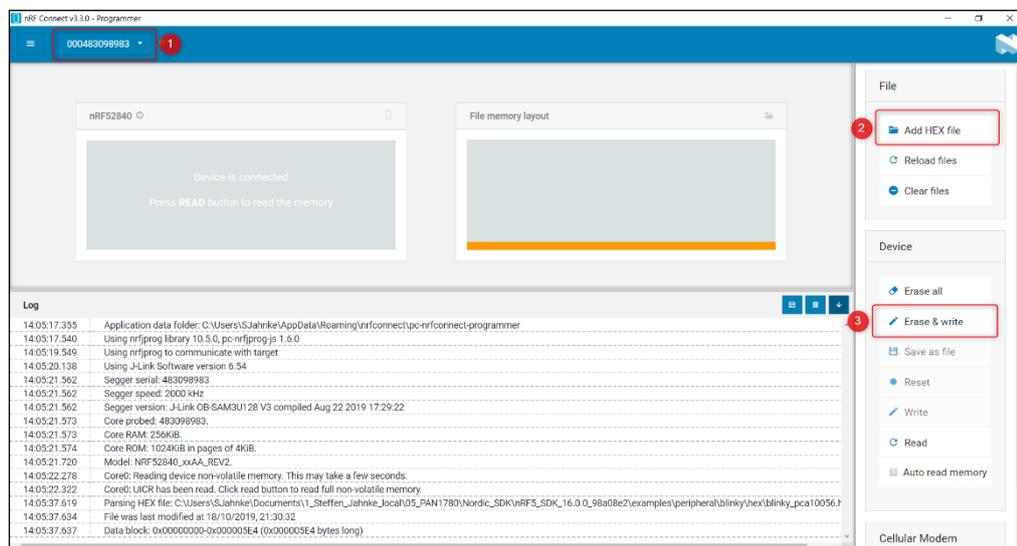
The following requirements must be met:

- ✓ **nRF Connect for Desktop** is installed on PC.
- ✓ The PAN1780 evaluation board is connected via USB cable on USB port X2 to the PC.

1. Open **nRF Connect for Desktop**.
2. Click **Open** to use the programmer module.



3. Select the preferred device in the drop down menu (1). Please see Segger ID on bottom of the PAN1780 ETU.



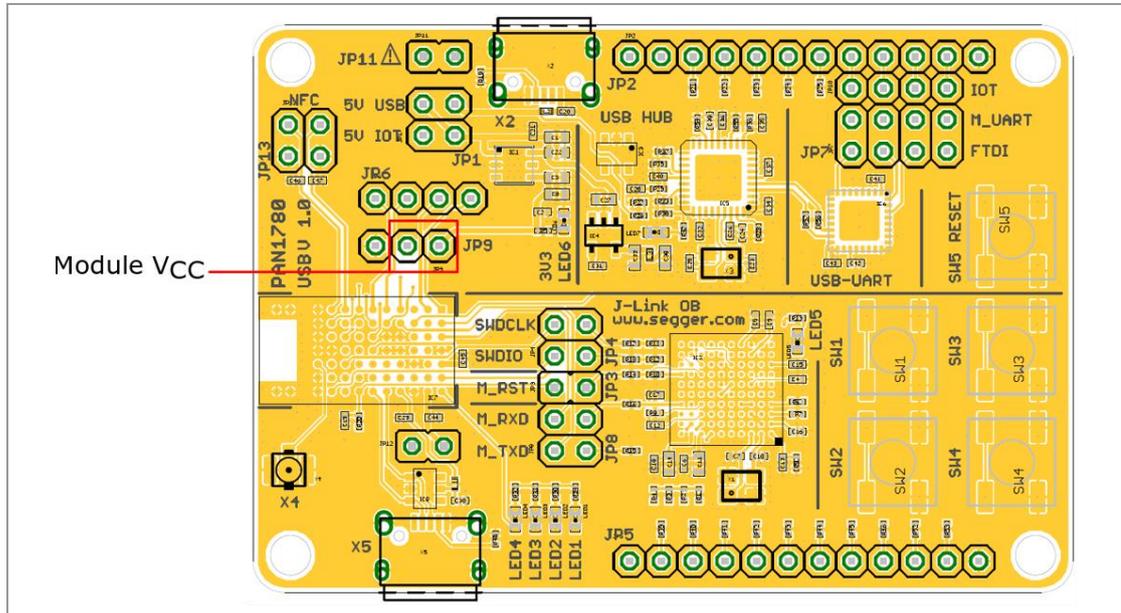
4. Click **Add HEX file** (2).
5. Add the precompiled firmware .hex-file from Nordic SDK folder
%SDK_Folder% > examples > ble_peripheral > ble_app_pwr_profiling > hex > ble_app_pwr_profiling_pca10056_s140.hex.
6. After the .hex-file was loaded successfully in nRF Connect, click **Erase & write** (3).
 ➔ Now the application **ble_app_pwr_profiling** will be flashed on the PAN1780 ETU.

5.1.2 Hardware

The current measurement equipment must be connected in series to the PAN1780.

For this purpose, jumper JP9 can be removed and the current measurement equipment can be connected over these two pins.

The following picture shows the position of jumper JP9 on the PCB.



5.2 How to Measure in System OFF Mode

After power on the device, the firmware `ble_app_pwr_profiling` will go into System OFF Mode automatically.

The following picture shows the results of the measurement: The measured current consumption is 201 nA.



5.3 How to Measure in Low Power Mode

After power on the device, the firmware `ble_app_pwr_profiling` will go into System OFF Mode automatically.

The System OFF Mode can be left by these ways:

- Press button 1 “SW1” on the ETU to enter the connectable mode.
- Press button 2 “SW2” on the ETU to enter the non-connectable mode.

In any of these configurations the same Low Power Mode is entered.

5.3.1 Connectable Mode

Press button “SW1” on the device to enter the connectable mode.

- The application advertises in connectable mode.

The following picture shows the result of the measurement: The measured current consumption is 401 nA.



5.3.2 Non-Connectable Mode

Press button “SW2” on the device to enter the non-connectable mode.

- The application advertises but does not accept an incoming connection.

The following picture shows the results of the measurement: The measured current consumption is 468 nA.



5.4 Conclusion

In the “PAN1780 Production Specification” typical current consumption values are given for the different modes which can be compared against the measured values.

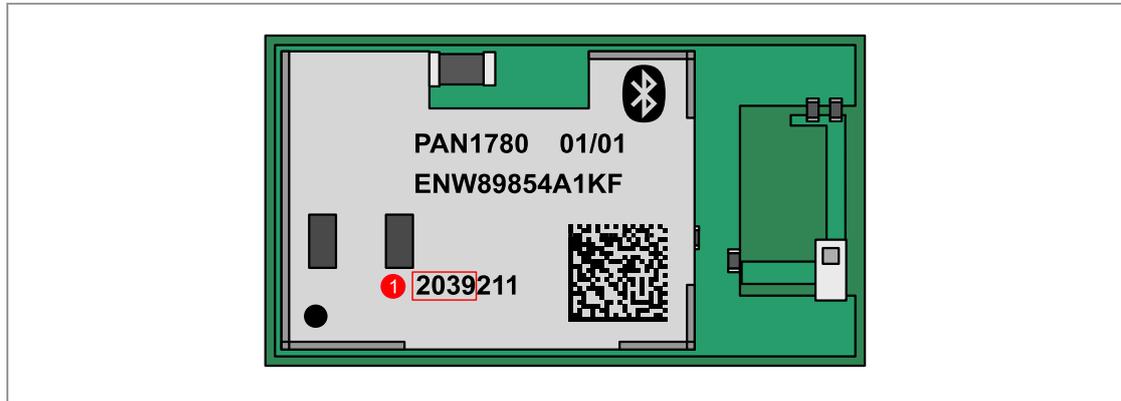
Mode	Typical Value	Measured Value	Unit
System OFF mode	400	201	nA
Connectable mode	970	401	
Non-connectable mode	970	468	

All measured current consumption values lie generously below the typical values given in the “PAN1780 Production Specification”.

6 Module Errata: Pre-configured Reset and NFC Pins

All PAN1780 modules manufactured before calendar week 42 of the year 2020 need special handling during production of a customer product.

The manufacturing date can be derived from the lot code **(1)** that is printed on every module.



The first two digits represent the year of the manufacturing, the following two digits represent the calendar week.

In this example the module was manufactured in calendar week 39 of the year 2020, so it needs special handling during production.

6.1 Conditions

The PAN1780 module is based on the nRF52840 chipset which offers the possibility to configure a custom pin as a reset pin and 2 fixed pins as NFC pins.

During manufacturing of the PAN1780 module these pins are configured for testing purposes following the settings of the Nordic development kit reference design:

- P0.18 is used as reset pin,
- P0.09 and P0.10 are configured as NFC pins.

Unfortunately, this configuration remains in the PAN1780 module.

6.2 Consequences

During production the customer usually must configure the reset and NFC pin configurations of the PAN1780 module to match the actual product design.

In case the customer's product is using P0.18 as the reset pin and using the NFC functionality, no further action is required because the PAN1780 module is already configured correctly.

In all other cases a workaround must be applied during production, so that a new configuration, matching the customer product, can be set.

6.3 Workaround

The reset and NFC pin configurations are stored in the non-volatile so-called UICR memory area of the PAN1780 module. This memory area can be reset to factory defaults easily. But because the module's Bluetooth Device Address and other PAN1780-specific information are stored in the same UICR memory, some care must be taken so that this information is not lost accidentally.

During manufacturing of a customer product, Nordic's tool "nrfjprog" can be used to perform the necessary tasks.

6.3.1 Save Information

Before the manufacturing can be done all PAN1780-specific information must be saved. This information is stored in addresses 0x10001080 and 0x10001084 of the UICR. The following commands must be executed and the results must be noted down for later use.



Bluetooth Device Addresses are unique!

Please note that every module has a unique Bluetooth Device Address, so this step must be done for every module individually.

"xxxxxx" is used as a placeholder and will be different for every module.

```
Execute nrfjprog.exe --memrd 0x10001080 --n 4
```

```
→ 0x10001080: 43xxxxxx
```

```
Execute nrfjprog.exe --memrd 0x10001084 --n 4
```

```
→ 0x10001080: 01030013
```

6.3.2 Factory Reset

Next a factory reset must be performed. This will clear the UICR completely, including the erroneous reset and NFC pin configurations that may be present.

```
Execute nrfjprog.exe --eraseall
```

```
→ Erasing user available code and UICR flash areas.  
Applying system reset.
```

6.3.3 Restore Information

All PAN1780-specific information that was previously saved, must be restored.

For this example, the following commands must be executed using the information that was previously saved:

Execute `nrfjprog.exe --memwr 0x10001080 --val 0x43xxxxxx`

```
→ Parsing parameters.  
Writing.
```

Execute `nrfjprog.exe --memwr 0x10001084 --val 0x01030013`

```
→ Parsing parameters.  
Writing.
```

6.3.4 Perform Manufacturing

At this point the manufacturing of the customer product can be done without further restrictions.

7 Contact Details

7.1 Contact Us

Please contact your local Panasonic Sales office for details on additional product options and services:

For Panasonic Sales assistance in the **EU**, visit

<https://eu.industrial.panasonic.com/about-us/contact-us>

Email: wireless@eu.panasonic.com

For Panasonic Sales assistance in **North America**, visit the Panasonic website “Sales & Support” to find assistance near you at

<https://na.industrial.panasonic.com/distributors>

Please visit the **Panasonic Wireless Technical Forum** to submit a question at

<https://forum.na.industrial.panasonic.com>

7.2 Product Information

Please refer to the Panasonic Wireless Connectivity website for further information on our products and related documents:

For complete Panasonic product details in the **EU**, visit

<http://pideu.panasonic.de/products/wireless-modules.html>

For complete Panasonic product details in **North America**, visit

<http://www.panasonic.com/rfmodules>