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Baseline integration and functional test

Bownce

Ball (C4 Sample) Anchor (C5 Sample)

Change History

Author	Date	Modification
ThG	13.01.2023	- BLE stability endurance test added
	Version 1.1	- Testing equipment added
		- Additional information added
		- Clarification about changes in DIS after finishing integration testing
ThG	04.05.2023	EOL Test changed. BT Advertising enable/disable commands added
	Version 1.2	
ThG	16.07.2024	Flash procedure to disable EOL Test in production environment without UART connection to the DUT
	Version 1.3	(Chapter 5.3)
ThG	01-09.2025	Added testprocedures for baseline 4.10/57 4.11/58 Anchor and
	Version 1.4	4.20/130 4.21/131Ball

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0 Preface

This manual is only intended for trained personnel use. The execution of the documented installations, manuals etc. may cause harm to people and damage this control device and connected devices or facilities if used by untrained people.

Please note: screenshots of smartphone devices are intended as example for the test staff. Screenshots does not necessarily reflect the behavior of the current device under test! Only the written text is decisive!

1 Related documents

Document	Version	File
Bownce BLE Uart protocol specification	1.5 as of 07.10.22	505014_001_7_B3_V15_bownce_ble_protocol_221007pub.pdf

2 Checklist for Baseline Build

Checklist Baseline build:

1. Check Version number in config.h
2. Check changelog
3. BMI and shutdown enabled
4. Off delay set to 3 minutes
5. **In case the nvData FLASH Layout has changed, change the Magic Key to ensure the nvData will be re-written after DFU Update**
6. Set build configuration to “release”
7. Recompile
8. Set Version number in dfu package buildscript
9. Run buildscript
10. Commit changes
11. Tag commit with “Vxx” and delivery date
12. Push branch to master
13. **After performing tests reflash device with the same version via DFU to make sure the bootloader is properly working**

3 Equipment used for testing

1. Phillips PM201 Multimeter for current measurement
2. UNI-T UT61E Multimeter for current measurement
3. Smartphone Wiko Lenny
4. Smartphone ZTE Blade 8
5. Smartphone Apple iPhone SE
6. nRF Connect App Version 4.26.0
7. nRF Toolbox Version 2.8.4 with DFU Library Version 1.10.0 (of DFU module)
8. Smaprtphone Doro 8050
9. Tablet Galaxy Tab A
10. GIE BLE Datalogger, see Appendix B
11. Bench power supply with adjustable current limiter @about 20mA
12. CR2023 Batteries

4 General considerations when testing

In general two different styles of test procedures are carried out:

- Tests that are made on the test bench (e.g. current consumption, on-off behaviour,...) → Integration tests. Typical integration tests are done by the development team after freezing the software and prior to carrying software out so someone else.
- Tests that are made with the completely assembled ball (but not necessarily with an functioning anchor!). These kind of test are made to reflect the experience of the user.
- **All test with the completely assembled ball must be done with proper rope tension. That means rope tension must be in the range between 1kg up to 2kg.**
- **Functional testing shall not be done by the core development team!**
- **Functional test shall be done with battery powered devices!**

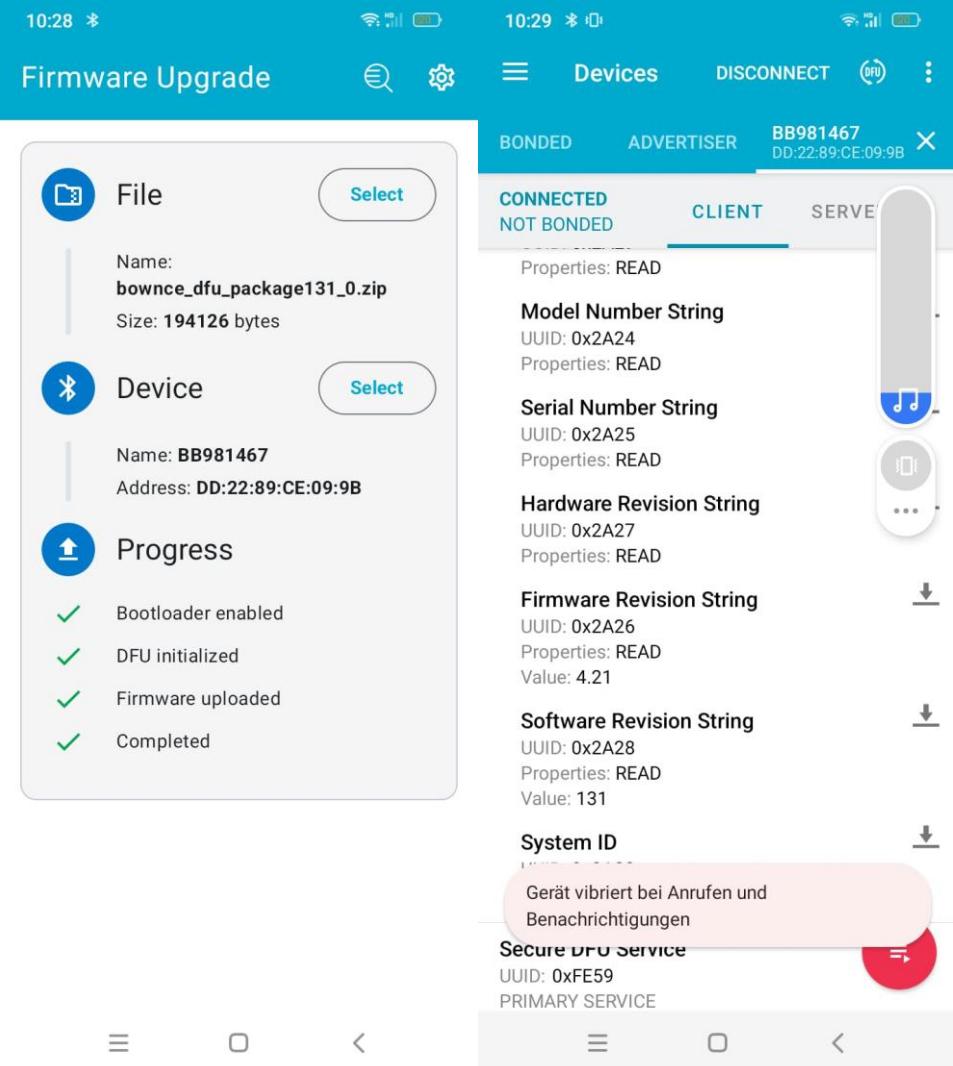
5 Functional tests for baseline 131 (Ball) and 58 (Anchor)

5.1 Description of changes

In 131 and 58 the unique device ID which is derived from the NORDIC processor ID is added to the BLE-UART frame which allready contain the information about the Power-Off-Delay

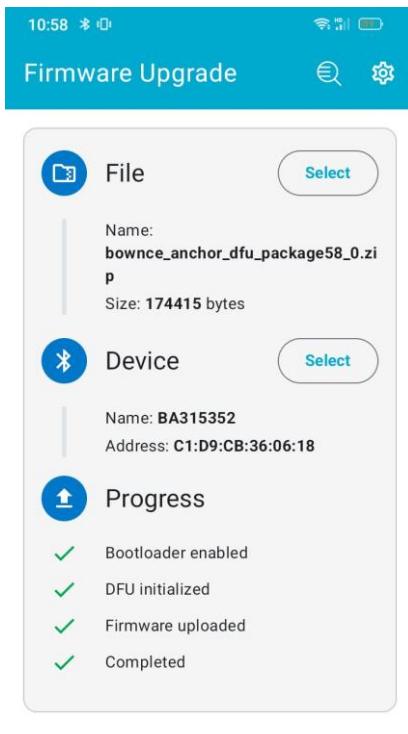
5.1.1 Ball

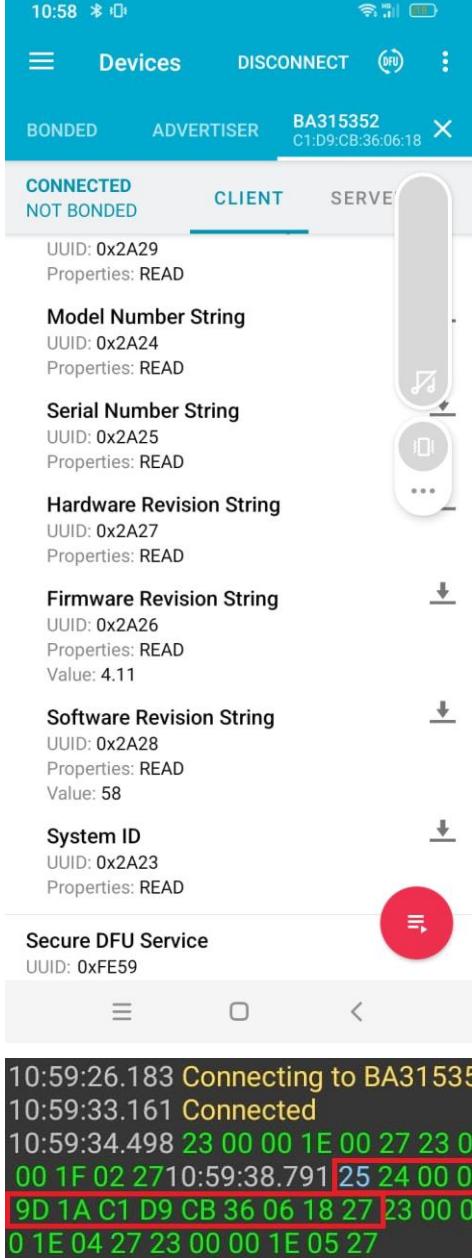
Functional Tests	
PCB Serial No.	TBD
FW Versions	4.21/138
Mechanics used	<ul style="list-style-type: none">- unmounted PCB- Powered by external powersource @3,0V

Teststep	#1
Description	Erase Flash, program baseline b120 with external tools and disable the EOL Test. Update via DFU to baseline b131. Connect with BLE terminal and read the info frame with BLE command ox25. Check the response
	 <pre> 10:29:49.261 Connecting to BB981467 ... 10:30:01.075 Connected 10:30:02.140 23 01 2E 12 00 00 04 86 00 00 19 00 04 00 27 23 01 34 5B 00 00 04 86 00 00 19 00 04 01 27 23 01 3A A5 00 00 04 86 00 00 19 00 04 02 27 23 01 40 EE 00 00 04 86 00 00 19 00 04 03 27 10:30:09.606 25 24 00 00 00 B4 00 00 00 B4 20 09 04 05 F1 67 E7 03 27 23 01 47 36 00 00 04 86 00 00 19 00 04 04 27 23 01 4D 7F 00 00 04 86 00 00 19 00 04 05 27 </pre>
Result/Deviation	OK

5.1.2 Anchor

Functional Tests	
PCB Serial No.	100499 (C4) Anchor
FW Versions	4.11/58
Mechanics used	<ul style="list-style-type: none">- unmounted PCB- Powered by external powersource @3,0V

Teststep	#1
Description	Erase Flash, program baseline b56 with external tools and disable the EOL Test. Update via DFU to baseline b58. Connect with BLE terminal and read the info frame with BLE command ox25. Check the response
	

	 <pre> 10:59:26.183 Connecting to BA315352 ... 10:59:33.161 Connected 10:59:34.498 23 00 00 1E 00 27 23 00 00 1E 01 27 23 00 00 1F 02 27 10:59:38.791 25 24 00 00 00 B4 00 00 00 B4 9D 1A C1 D9 CB 36 06 18 27 23 00 00 1E 03 27 23 00 0 0 1E 04 27 23 00 00 1E 05 27 </pre>
Result/Deviation	OK

6 Integration and functional tests for baseline 130 (Ball) and 57 (Anchor)

6.1 Description of changes

Both devices (Ball and Anchor) shall provide functionality to change the Power-Off-Delay via BLE UART command.

The Power-Off-Delay is the time (scaled in seconds) the devices switch to Off-Mode after the last captured movement event by one of the acceleration sensors. E.g. if the Power-Off-Delay is set to 180 seconds, the device switches to Off-Mode 3 Minutes after the last movement of the device.

Compared to baselines 120/56 following changes are made:

- The Power-Off-Delay is no longer derived from a constant value stored in the program memory, instead it is derived from a parameter in the nvData area of the flash memory
- On PON the nvData is read out of the flash memory, and the Power-Off-Delay gets initialized.
- In nvData one “spare” parameter is used. In further baselines this spare parameter was initialized with “0”. Therefore a plausibility check of the Power-Off-Delay is made right after initialization. **In case the device was updated via DFU, the nvData will contain “0” where the value for the Power-Off-Delay was expected.** In such case the Power-Off-Delay will be initialized with the (original) value from program memory and the nvData will be re-written.
- A new BLE UART command to update the **Power-Off-Delay** parameter in nvData was implemented
- A new BLE UART command to read the current value of the Power-Off-Delay was implemented

6.2 Anchor integration tests

Bench Tests	
PCB Serial No.	100499 (C4)
FW Versions	4.10/57
Mechanics used	- unmounted PCB - Powered by external powersource @3,0V

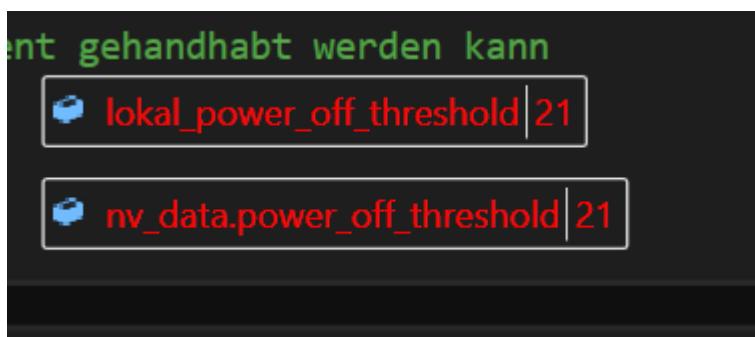
Teststep	#1
Description	Erase Flash, Start debugging session with debug version of b57, set breakpoint after initialization of nvData

	<pre> 766 flash_init(); 767 nvData_init(); 768 /* 769 *@@ 4.10_ Hier Abfrage ob Power Off Threshold plausiblen Wert enthält. 770 *Dies ist Notwendig, da bis 4.9 im nvData an spare5 eine 0 geschrieben wurde. 771 *Beim ersten Start von 4.10 würde daher der Power Off Threshold auf 0 gesetzt werden, ohne Möglichkeit dies zu 772 *überschreiben, da das Device sofort wieder in den Power Off Mode gehen würde 773 */ 774 if ((nv_data.power_off_threshold < POWER_DOWN_DELAY_MIN) 775 (nv_data.power_off_threshold > POWER_DOWN_DELAY_MAX)) 776 { 777 //dies muss der erste Start von 4.10 sein...und zwar auf einem Device das gültiges nvData hat, also mit einer 778 //Vorgängerversion den EOL Test passiert hat... 779 nv_data.power_off_threshold = POWER_DOWN_DELAY; 780 nvData_update(); 781 } 782 /* 783 //lokal power off threshold geteilt durch 1.5 da wir auf dem Anker eine Zeitscheibe von 1.5 Sekunden haben 784 //dies muss auch berücksichtigt werden, wenn der Threshold via BLE Uart zurückgelesen wird. 785 //gespeichert wird in jedem Fall die Dauer in Sekunden, damit dies in der APP konsistent gehandhabt werden kann 786 lokal_power_off_threshold = nv_data.power_off_threshold ; //@@ 4.10_ 787 #if (DISABLE_EOL_TEST == 1) 788 nv_data.spare4 = 12345; 789 #endif 790 if (nv_data.spare4 != 12345) 791 { </pre>
Result/Deviation	<p>nv_data.power_off_threshold musst be initialized with 120 (default value)</p> <p>OK</p>

Teststep	#2
Description	<p>Restart the Device and measure time until the device switches to Off-Mode</p> <p>In Off-Mode shake the device to wake it up again, and check the value from teststep #1 again</p>
	<pre> be von 1.5 Sekunden haben esen wird. sistent gehandhabt werden kann lokal_power_off_threshold 120 nv_data.power_off_threshold 120 </pre>
Result/Deviation	<p>Device must go to Off-Mode after 3 Minutes (120 * 1,5 = 180 Seconds)</p> <p>OK</p>

Teststep	#3
Description	<p>Restart the device, connect via BLE-UART and program the Power-Off-Delay to 30 Seconds:</p> <p>0x38 0x00 0x00 0x00 0x20 0x27</p> <p>Read the Value back:</p> <p>0x25</p>

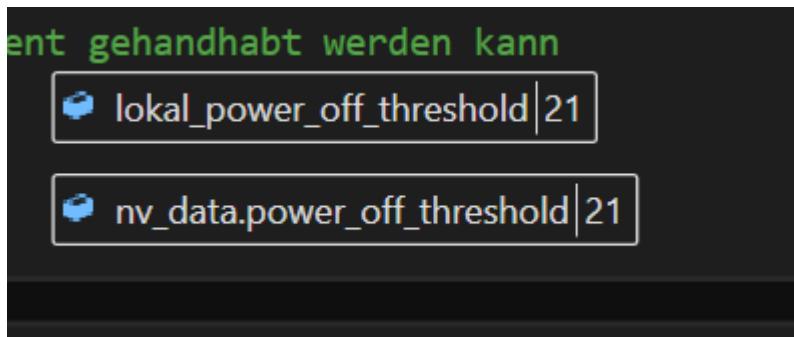
	<pre> 10:34:16.534 Connected 10:34:17.772 23 00 00 1E 00 27 23 00 00 1E 01 27 23 00 00 1E 02 27 10:34:21.121 25 24 00 00 00 B4 00 00 00 B 4 27 23 00 00 1E 03 27 23 00 00 1E 04 27 23 00 00 1E 0 5 27 23 00 00 1E 06 27 23 00 00 1E 07 27 23 00 00 1E 0 8 27 23 00 00 1E 09 27 23 00 00 1E 0A 10:34:32.740 27 23 00 00 1E 0B 27 23 00 00 1E 0C 27 2 3 00 00 1E 0D 27 23 00 00 1E 0E 27 10:34:39.522 38 00 00 00 20 27 40 23 00 00 1E 0F 27 23 00 00 1E 10 27 23 00 00 1E 11 27 23 00 00 1E 12 27 10:34:45.372 25 24 00 00 00 1F 00 00 00 B4 27 23 00 00 1E 13 27 23 00 00 1E 14 27 23 00 00 1E 15 27 10:34:49.726 Disconnected </pre>
	<p>First read: 0xB4/0xB4 → 180/180 Write 0x20 → 32 Seconds Second read: 0x1F/0xB4 → 31/180 Seconds Deviation: Second read is 31 Seconds, write was 32 Seconds. Since we need to scale the value internally to timeslices of 1.5 seconds, the deviation is a result of the calculation and cast to float and back to integer (+/- 1 second is accepted)</p>
Result/Deviation	OK

Teststep	#4
Description	<p>Wait until the device went into Off-Mode Restart the device by shaking it</p> 
	<p>Deviation: stored value is 21 * 1.5 Sec. = 31.5 Seconds. Since we use integer arithmetic the Power-Off-Delay will be 31 Seconds. Deviation by +/- 1 second will be accepted</p>
Result/Deviation	OK

Teststep	#5
Description	Wait until the device went into Off-Mode. Device went to Off-Mode after approx. 32 seconds.
Result/Deviation	OK

Teststep	#6		
Description	Connect the device and try to write a value below 30 Seconds		
	<pre>11:08:39.540 Connected 11:08:40.056 23 00 00 1E 00 27 23 00 00 1E 01 27 23 00 00 1E 02 27 23 00 00 1E 03 27 23 00 00 1E 04 27 23 00 00 1E 05 27 23 00 00 1E 06 27 23 00 00 1E 07 27 23 00 00 1E 08 27 23 00 00 1E 09 27 23 00 00 1E 0A 11:08:55.042 27 23 00 00 1E 0B 27 23 00 00 1E 0C 27 2 3 00 00 1E 0D 27 23 00 00 1E 0E 27 23 00 00 1E 0F 27 2 3 00 00 1E 10 27 23 00 00 1E 11 27 23 00 00 1E 12 27 2 3 00 00 1E 13 27 23 00 00 1E 14 27 23 00 00 1E 15 27 2 3 00 00 1E 16 27 23 00 00 1E 17 27 23 00 00 1E 18 27 2 3 00 00 1E 19 27 23 00 00 1E 1A 27 23 00 00 1E 1B 271 1:09:20.845 38 00 00 00 1D11:09:20.952 38 00 00 00 1D 11:09:21.190 38 00 00 00 1D 23 00 00 1E 1C 27 23 00 0 0 1E 1D 27 23 00 00 1E 1E 27 23 00 00 1E 1F 27 23 00 0 0 1E 20 27 23 00 00 1E 21 27 23 00 00 1E 22 27 11:09:32.429 Disconnected</pre> <p>Device did not respond with ACK (0x40)</p> <p>en wird. stent gehandhabt werden kann</p> <table border="1"> <tr> <td><input checked="" type="checkbox"/> lokal_power_off_threshold 21</td> </tr> <tr> <td><input checked="" type="checkbox"/> nv_data.power_off_threshold 21</td> </tr> </table> <p>After PON the Power-Off-Delay stays at the value programmed in the previous test step.</p>	<input checked="" type="checkbox"/> lokal_power_off_threshold 21	<input checked="" type="checkbox"/> nv_data.power_off_threshold 21
<input checked="" type="checkbox"/> lokal_power_off_threshold 21			
<input checked="" type="checkbox"/> nv_data.power_off_threshold 21			
Result/Deviation	OK		

Teststep	#7
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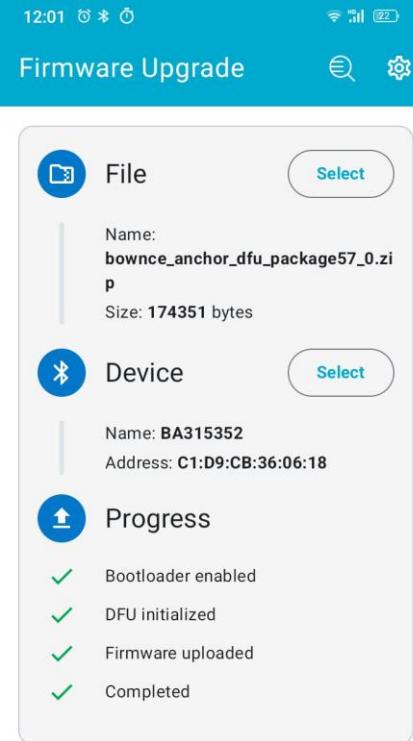
Description	Connect the device and try to write a value above 3600 Seconds
	<pre>11:17:36.421 Connected 11:17:37.711 23 00 00 1E 00 27 23 00 00 1E 01 27 23 00 00 1E 02 27 23 00 00 1E 03 27 23 00 00 1E 04 27 23 00 00 1E 05 27 23 00 00 1E 06 27 23 00 00 1E 07 27 23 00 00 1E 08 27 11:17:49.813 38 00 00 0E 11 23 00 00 1E 09 27 23 00 00 1E 0A 11:17:52.681 27 23 00 00 1E 0B 27 11:17:55.055 Disconnected</pre> <p>Device did not respond with ACK (0x40)</p> 
	After PON the Power-Off-Delay stays at the value programmed in the previous test step.
Result/Deviation	OK

6.3 Anchor functional tests

Teststep	#1
Description	<p>Program the device with previous baseline 56. Disable the EOL Test.</p> <p>Update the device via DFU with FW package 57.</p> <p>Check that the device stays active for 180 seconds (default value)</p> <p>Read the nvData from Flash memory with external tool, check that the Power-Off-Delay value is initialized with 120 (180 Seconds)</p>

	<pre>C:\Users\thomas>nrfjprog --memrd 0x77000 --n 128 0x00077000: 00123424 00000000 00000000 00654324 \$4.....\$Ce. 0x00077010: 00000064 000009C4 00000000 000000BA d..... d..... 0x00077020: 000003E8 00003039 00000000 00000078 90.....x.. x.. 0x00077030: 00000000 00000000 00000000 00000000 0x00077040: 00000000 00000000 00000000 00000000 0x00077050: FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFF 0x00077060: FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFF 0x00077070: FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFF </pre>
Result/Deviation	OK

Teststep	#2
Description	<p>Final Test to ensure functionality of the DFU bootloader:</p> <p>Clear the device memory, flash the HEX file from b57, disable the EOL Test via EOL-UART, re-program 57 via DFU. This is to ensure that the bootloader was properly configured and merged to the production HEX file</p>

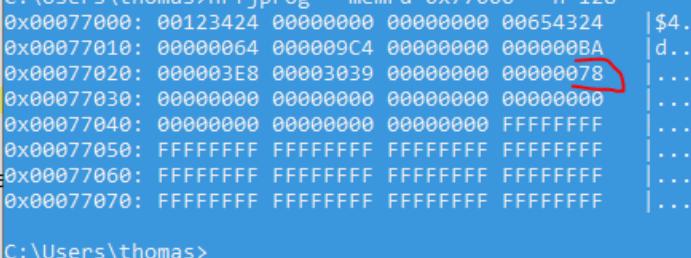
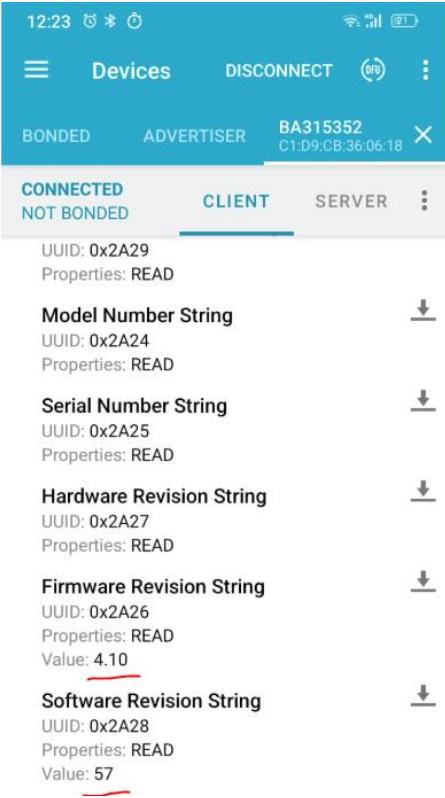


nvData is valid and updated after first start:

```
C:\Users\thomas>nrfjprog --memrd 0x77000 --n 128
0x000077000: 00123424 00000000 00000000 00654324 | $4.....$Ce..
0x000077010: 00000064 000009C4 FFFFFFFF 000000BA | d.....|.
0x000077020: 000003E8 00003039 00000000 00000078 | .....90.....x..|
0x000077030: 00000000 00000000 00000000 00000000 | .....|.
0x000077040: 00000000 00000000 00000000 FFFFFFFF | .....|.
0x000077050: FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFF | .....|.
0x000077060: FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFF | .....|.
0x000077070: FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFF | .....|.
```

Result/Deviation	OK
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Teststep	#3
Description	Production programming with disabled EOL Test (in house production GIE). For the programming without EOL the procedure and the nvData from b56 will be used. This is possible, since b57 will update the nvData on the first start. See teststep #1

	<pre>C:\Users\thomas>nrfjprog --memrd 0x77000 --n 128 0x00077000: 00123424 00000000 00000000 00654324 0x00077010: 00000064 000009C4 00000000 000000BA 0x00077020: 000003E8 00003039 00000000 00000078 0x00077030: 00000000 00000000 00000000 00000000 0x00077040: 00000000 00000000 00000000 FFFFFFFF 0x00077050: FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFF 0x00077060: FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFF 0x00077070: FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFF</pre>  
Result/Deviation	OK

6.4 Ball integration tests

Bench Tests	
PCB Serial No.	TBD (C4)
FW Versions	4.20/130

Mechanics used	- unmounted PCB - Powered by external powersource @3,0V
----------------	------------------------------------------------------------

Teststep	#1
Description	Erase Flash, Start debugging session with debug version of b130, set breakpoint after initialization of nvData
	<pre> 725 flash_init(&flash_config); 726 nvData_init(); 727 /* 728 *@@_4.20_ Hier Abfrage ob Power Off Threshold plausiblen Wert enthält. 729 *Dies ist Notwendig, da bis 4.19/130 im nvData an spare5 eine 0 geschrieben wurde. 730 *Beim ersten Start von 4.20/130 würde daher der Power Off Threshold auf 0 gesetzt werden, ohne Möglichkeit 731 *überschreiben, da das Device sofort wieder in den Power Off Mode gehen würde 732 */ 733 if ((nv_data.power_off_threshold < POWER_DOWN_DELAY_MIN) 734 (nv_data.power_off_threshold > POWER_DOWN_DELAY_MAX)) 735 { 736 //dies muss der erste Start von 4.20/130 sein...und zwar auf einem Device das gültiges nvData hat, also 737 //Vorgängerversion den EOL Test passiert hat... 738 nv_data.power_off_threshold = POWER_DOWN_DELAY; 739 nvData_update(); 740 } 741 742 lokal_power_off_threshold = nv_data.power_off_threshold; //@@_4.20_ 743 #if (DISABLE_EOL_TEST == 1) 744 nv_data.spare4 = 12345; 745 #endif 746 747 if (nv_data.spare4 != 12345) 748 </pre> <p style="text-align: right;">nv_data.power_off_threshold 180 lokal_power_off_threshold 180</p>
Result/Deviation	nv_data.power_off_threshold musst be initialized with 180 (3 Minutes, timeslice 1 Second) (default value) OK

Teststep	#2
Description	Restart the Device and measure time until the device switches to Off-Mode In Off-Mode shake the device to wake it up again, and check the value from teststep #1 again
	<pre>//@@ _4.20_ nv_data.power_off_threshold 180 lokal_power_off_threshold 180</pre>
Result/Deviation	Device must go to Off-Mode after 3 Minutes (180 Seconds) OK

Teststep	#3
Description	Restart the device, connect via BLE-UART and program the Power-Off-Delay to 32 Seconds: 0x38 0x00 0x00 0x00 0x20 0x27 Read the Value back:

	0x25
	<pre> 10:49:42.822 Connecting to BB981467 ... 10:49:54.949 Connected 10:49:56.477 23 00 98 65 00 00 02 D7 00 00 1B 00 04 0 0 27 23 00 9E BC 00 00 02 D7 00 00 1B 00 04 01 27 23 0 0 A5 14 00 00 02 D7 00 00 1B 00 04 02 27 23 00 AB 6B 0 0 00 01 3D 00 00 1B 00 04 03 27 23 00 B1 C2 00 00 01 3 D 00 00 1B 00 04 04 27 23 00 B8 19 00 00 01 3D 00 00 1 B 00 04 05 27 23 00 BE 71 00 00 01 3D 00 00 1B 00 04 0 6 27 23 00 C4 C9 00 00 01 3D 00 00 1B 00 04 07 27 23 0 0 CB 22 00 00 01 3D 00 00 1B 00 04 08 27 10:50:12.433 38 00 00 00 20 27 40 23 00 D1 77 00 00 01 3D 00 00 1B 00 04 09 27 23 00 D7 CE 00 00 01 3D 00 00 1B 00 04 0A 10:50:16.413 27 23 00 DE 26 00 00 02 87 00 00 1B 00 0 4 0B 27 23 00 E4 7E 00 00 02 87 00 00 1B 00 04 0C 27 1 0:50:21.143 25 24 00 00 00 20 00 00 00 B4 00 00 00 27 23 00 EA D6 00 00 02 87 00 00 1B 00 04 0D 27 23 00 F1 2E 00 00 02 87 00 00 1B 00 04 0E 27 23 00 F7 87 00 00 02 87 00 00 1B 00 04 0F 27 23 00 FD E0 00 00 02 87 00 00 1B 00 04 10 27 10:50:28.907 Disconnected </pre> <p>Write 0x20 → 32 Seconds Second read: 0x20/0xB4 → 32/180 Seconds</p> <p>In contrast to the Anchor, no deviation is accepted since the ball has a 1 second timeslice. No integer-float-integer transformation is needed!</p>
Result/Deviation	OK

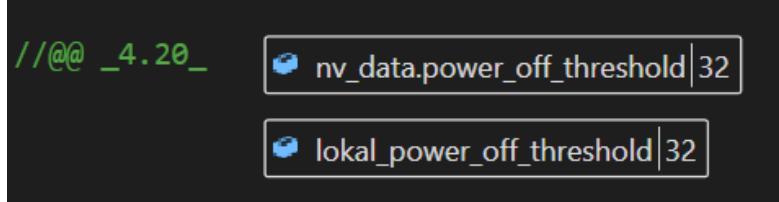
Teststep	#4
Description	<p>Wait until the device went into Off-Mode Restart the device by shaking it</p> <pre> //@@ _4.20_ nv_data.power_off_threshold 32 lokal_power_off_threshold 32 </pre>
	<p>No deviation accepted. See step #3!</p>

Result/Deviation	OK
-------------------------	----

Teststep	#5
Description	Wait until the device went into Off-Mode. Device went to Off-Mode after approx. 32 seconds.
Result/Deviation	OK

Teststep	#6
Description	Connect the device and try to write a value below 30 Seconds <pre>11:00:10.649 Connected 11:00:10.649 23 00 24 08 00 01 00 00 05 04 1A 34 00 0 0 27 23 00 29 9D 00 01 00 00 05 04 1A 34 00 01 27 23 0 0 2F EF 00 01 00 00 05 04 1A 34 00 02 27 23 00 36 43 0 0 01 03 C6 05 04 1A 34 04 03 27 23 00 3C 94 00 01 03 C 6 05 04 1A 34 04 04 27 23 00 42 E8 00 01 03 C6 05 04 1 A 34 04 05 27 23 00 49 3A 00 01 03 C6 05 04 1A 34 04 0 6 27 23 00 4F 8C 00 01 03 C6 05 04 1A 34 04 07 27 23 0 0 55 DE 00 01 03 C6 05 04 1A 34 04 08 27 11:00:27.530 38 00 00 00 1D 27 23 00 5C 32 00 01 03 C6 05 04 1A 34 04 09 27 11:00:36.241 Connection lost</pre> Device did not respond with ACK (0x40) <pre>//@@ _4.20_ nv_data.power_off_threshold 32 lokal_power_off_threshold 32</pre> After PON the Power-Off-Delay stays at the value programmed in the previous test step.
Result/Deviation	OK

Teststep	#7
Description	Connect the device and try to write a value above 3600 Seconds

	<pre>11:03:45.162 Connected 11:03:46.768 23 00 1C EB 00 00 00 00 00 00 00 00 00 00 00 00 00 0 0 27 23 00 23 3B 00 00 00 00 00 00 00 1A 00 00 01 2711:0 3:49.995 38 00 00 0E 11 27 23 00 29 8D 00 00 00 00 00 00 00 1A 00 00 02 27 23 00 2F DD 00 00 02 D6 00 00 1A 00 04 03 27 23 00 36 30 00 00 02 D6 00 00 1A 00 04 04 27 11:03:56.364 25 24 00 00 00 20 00 00 00 20 00 00 00 00 00 27 23 00 3C 81 00 00 02 D6 00 00 1A 00 04 05 27 23 00 42 D0 00 00 02 D6 00 00 1A 00 04 06 27 23 00 49 22 00 00 02 D6 00 00 1A 00 04 07 27</pre> <p>Device did not respond with ACK (0x40)</p>  <p>After PON the Power-Off-Delay stays at the value programmed in the previous test step.</p>
Result/Deviation	OK

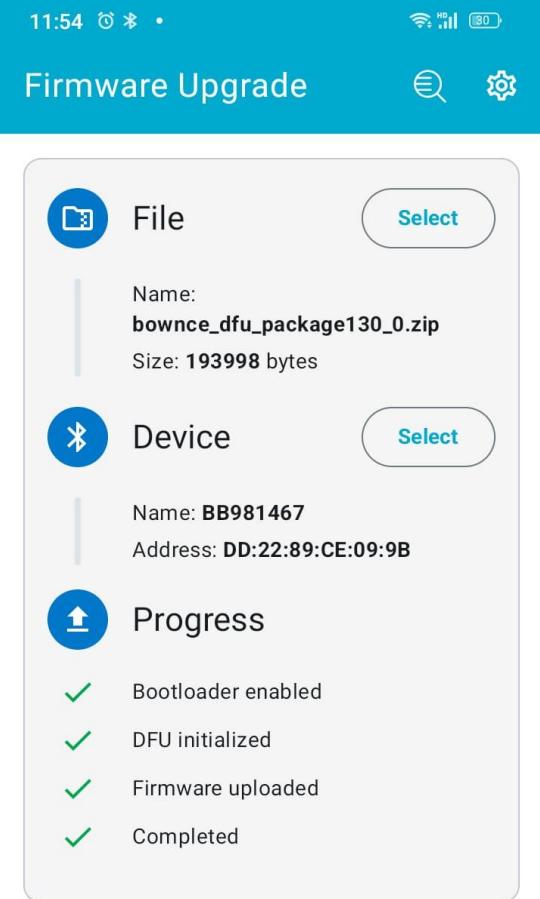
6.5 Anchor functional tests

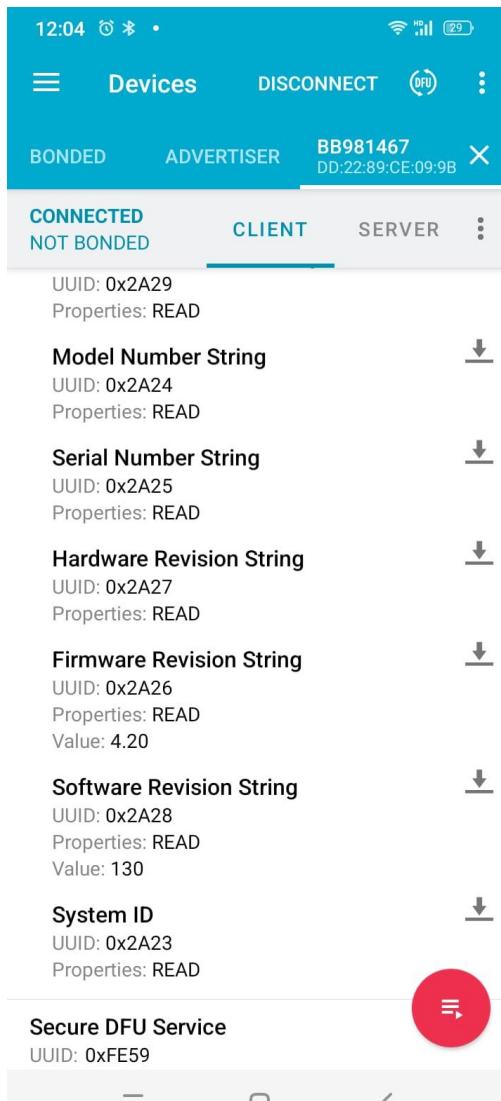
Teststep	#1
Description	<p>Program the device with previous baseline 120. Disable the EOL Test.</p> <p>Update the device via DFU with FW package 130.</p> <p>Check that the device stays active for 180 seconds (default value)</p> <p>Read the nvData from Flash memory with external tool, check that the Power-Off-Delay value is initialized with 120 (180 Seconds)</p>
	 <p>In comparison nvData from 120:</p>

**Baseline Test Bounce Ball (C4 Sample),
Anchor (C5 Sample)**

	<pre>C:\Users\thomas>nrfjprog --memrd 0x77000 --n 128 0x00077000: 00223479 00000000 00000000 00635344 0x00077010: 000003E8 000003E8 0000012C 0000001E 0x00077020: 00000000 000000C8 00003039 00000000 0x00077030: 00000000 00000000 00000000 00000000 0x00077040: 00000000 00000000 00000000 00000000 0x00077050: 00000000 00000000 00000000 00000000 0x00077060: 00000000 00000000 00000014 00000000 0x00077070: 000000FF FFFFFFFF FFFFFFFF FFFFFFFF</pre>	y4".....DSc. ,..... 90.....
Result/Deviation	OK	

Teststep	#2
Description	Final Test to ensure functionality of the DFU bootloader: Clear the device memory, flash the HEX file from b130, disable the EOL Test via EOL-UART, re-program b130 via DFU. This is to ensure that the bootloader was properly configured and merged to the production HEX file

	
Result/Deviation	OK

Teststep	#3
Description	Production programming with disabled EOL Test (in house production GIE). For the programming without EOL the procedure and the nvData from b120 will be used. This is possible, since b120 will update the nvData on the first start. See teststep #1
	<pre>C:\Users\thomas>nrfjprog --memrd 0x77000 --n 128 0x000077000: 00223479 00000000 00000000 00635344 y4".....DSc. 0x000077010: 000003E8 000003E8 0000012C 0000001E 0x000077020: 00000000 000000C8 00003039 000000B4 90..... 0x000077030: 00000000 00000000 00000000 00000000 0x000077040: 00000000 00000000 00000000 00000000 0x000077050: 00000000 00000000 00000000 00000000 0x000077060: 00000000 00000000 00000014 00000000 0x000077070: 000000FF FFFFFFFF FFFFFFFF FFFFFFFF </pre> 
Result/Deviation	OK

7 Changes in firmware after finishing Integration tests:

7.1 Anchor 54→55/Ball 104→105

Changes in the firmware were made after the integration test were finished and passed. From Versions 4.8/54 → 4.8/55 (Anchor) and 4.18/104 → 4.18/105 (Ball) the static information in the DIS were changed. These information are stored as constants in the non volatile memory of the Microcontroller. After changing the constants and preparing the distribution package (HEX and bin files) the distribution package (55, 105) were compared on binary level against the tested version (54, 104). No changes outside of the non volatile memory area where the constants are stored were found. It is proofed that there are no changes in control flow or data memory of the firmware 55 and 105 compared to 54 and 104.

7.2 Anchor 55→56/Ball 105→120

The current integration tests are carried out by using FW Versions 4.8/54 and 4.18/104. Based on Versions 4.8/55 and 4.18/105 (see above) changes in the EOL Testmode were made. These changes are considered not to affect the rest of the (functional)firmware by code review and risk analysis. The EOL Test firmware is isolated from the functional part of the firmware, and since the EOL Test is completely disabled after EOL Test there must be no side effects between EOL and functional part of the firmware.

The following tests are made to ensure the functionality of EOL test firmware:

7.2.1 Ball

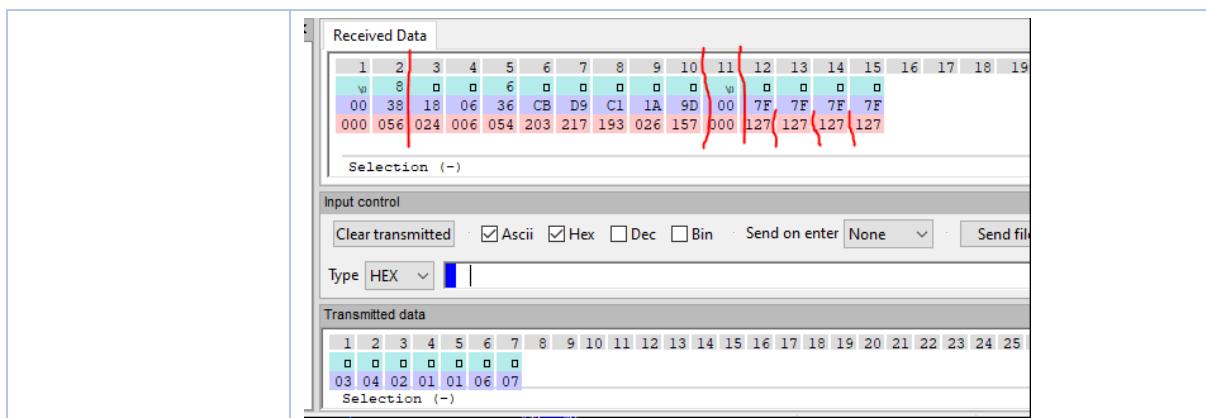
Bench Tests	
PCB Serial No.	100552 (C4)
FW Versions	4.19/120
Mechanics used	- unmounted PCB - Powered by external powersource @3,0V

Teststep	0
Description	Repower device after flashing/firmware update Check Power consumption Power consumption shall be 5.2 mA +- 0,2mA @ 3,0V
Result/Deviation	OK



Teststep	1
Description	<p>Repower device after flashing/firmware update to 120. Make sure Flash was erased completely including nvData</p> <p>After repowering LED must flash red 1/second. Red LED indicates that the EOL UART is enabled and the device is in EOL mode.</p> <p>Try to scan for the Device. Device must not be visible and must not transmit advertising packages</p>
Result/Deviation	OK

Teststep	2
Description	<p>Check UART communication. Connect the device via 3V FTDI cable.</p> <p>See chapter 8.1.7 on how to connect UART interface!</p> <p>Test all available UART commands. Make sure UART commands that does not respond with result must send ACK (127) back to the terminal</p>
Result/Deviation	OK

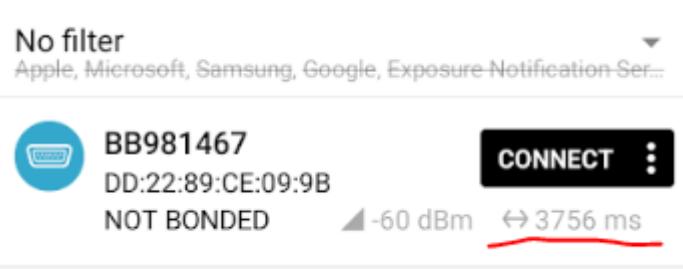


Teststep	2
Description	<p>Perform UART command 0x06 (Adv. Enable) Device must start advertising immediately. Latest after 1005ms. Check if the advertising interval is about 1000ms (Note: Nordic BLE scanner needs some advertising packages received in order to calculate the time gap between the packages)</p>
Result/Deviation	OK
	<p>No filter Apple, Microsoft, Samsung, Google, Exposure Notification Ser...</p> <p>BB981467 DD:22:89:CE:09:9B CONNECT : NOT BONDED -57 dBm ↳ 1005 ms</p>

Teststep	3
Description	<p>Perform UART command 0x07 (Adv. disable) Device must stop advertising immediately. Try to enable/disable advertising for a couple of times. Check if device is visible/invisible by the BLE scanner</p>
Result/Deviation	OK

Teststep	4
Description	<p>Perform UART command 0x09 (finally disable EOL Uart) Check if command responds with ACK (127) Reboot the device (Power-Off/On cycle)</p>

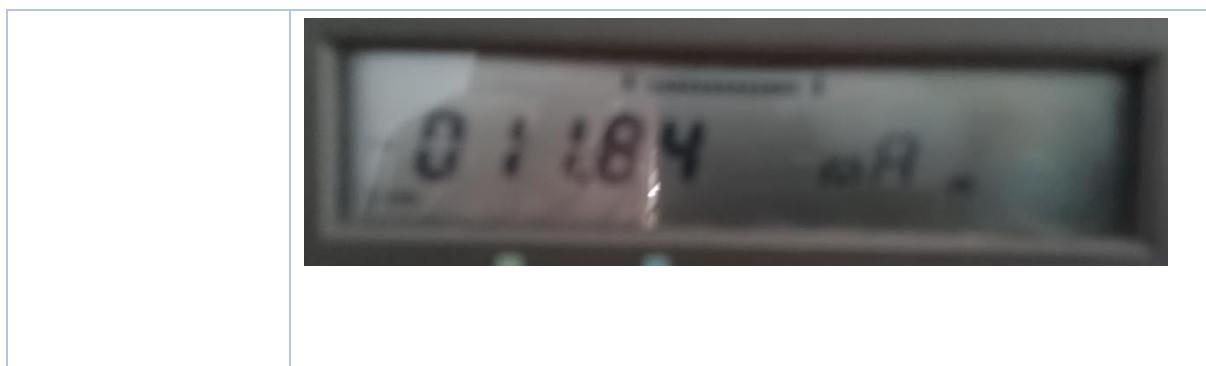
	LED on device must flash green after repowering, since EOL Uart is disabled now!
Result/Deviation	OK

Teststep	5
Description	Scan for the device with the BLE scanner. Device must be visible (advertising). The Advertising interval must be 3750ms.
Result/Deviation	OK
	

7.2.2 Anchor

Bench Tests	
PCB Serial No.	100499 (C5)
FW Versions	4.9/56
Mechanics used	<ul style="list-style-type: none"> - unmounted PCB - Powered by external powersource @3,0V

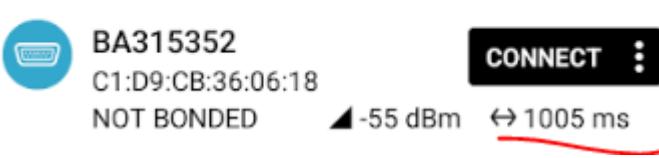
Teststep	0
Description	Repower device after flashing/firmware update Check Power consumption Power consumption shall be 10 mA +- 2mA @ 3,0V
Result/Deviation	OK



Teststep	1
Description	<p>Repower device after flashing/firmware update to 120. Make sure Flash was erased completely including nvData</p> <p>After repowering LED must flash red 1/second. Red LED indicates that the EOL UART is enabled and the device is in EOL mode.</p> <p>Try to scan for the Device. Device must not be visible and must not transmit advertising packages</p>
Result/Deviation	OK Device is not visible in BLE scanner

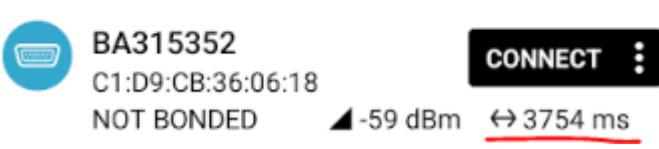
Teststep	2
Description	<p>Check UART communication. Connect the device via 3V FTDI cable.</p> <p>See chapter 9.1.7 on how to connect UART interface!</p> <p>Test all available UART commands. Make sure UART commands that does not respond with result must send ACK (127) back to the terminal</p>
Result/Deviation	OK <i>No screenshot available!</i>

Teststep	2
Description	<p>Perform UART command 0x06 (Adv. Enable)</p> <p>Device must start advertising immediately. Latest after 1000ms.</p> <p>Check if the advertising interval is about 1000ms (Note: Nordic BLE scanner needs some advertising packages received in order to calculate the time gap between the packages)</p>

Result/Deviation	OK
	<p>No filter Apple, Microsoft, Samsung, Google, Exposure Notification Ser...</p>  <p>BA315352 C1:D9:CB:36:06:18 NOT BONDED -55 dBm 1005 ms</p> <p>CONNECT :</p>

Teststep	3
Description	<p>Perform UART command 0x07 (Adv. disable) Device must stop advertising immediately. Try to enable/disable advertising for a couple of times. Check if device is visible/invisible by the BLE scanner</p>
Result/Deviation	OK

Teststep	4
Description	<p>Perform UART command 0x09 (finaly disable EOL Uart) Check if command responds with ACK (127) Reboot the device (Power-Off/On cycle) LED on device must flash green after repowering, since EOL Uart is disabled now!</p>
Result/Deviation	OK

Teststep	5
Description	Scan for the device with the BLE scanner. Device must be visible (advertising). The Advertising interval must be 3750ms.
Result/Deviation	OK
	<p>No filter Apple, Microsoft, Samsung, Google, Exposure Notification Ser...</p>  <p>BA315352 C1:D9:CB:36:06:18 NOT BONDED -59 dBm 3754 ms</p> <p>CONNECT :</p>

Note: Deviations in measured advertising interval with the nRF Connect App from +/- 10ms are accepted!

7.3 Anchor Build 56/Ball Build 120

Changes are made to the flash programming procedure only, not to the code itself. Therefore the build/version numbering is still the same!

To make it possible to flash program the devices in a production environment without having UART connection to devices the EOL test can be skipped by writing a magic number to the nvData area in the flash memory.

In general one page of the flash memory (starting at 0x0077000) is dedicated to store non volatile data such as calibration values and/or the device name. The initial values stored in the nvData area are not carried out by the "usual" HEX file, instead of that at the very first PON of the device the firmware recognizes uninitialized nvData. In this case the firmware then initializes the nvData area and writes the initial default values into the area. The initial dataset does NOT contain the information about successfully passed EOL test. Therefore the firmware branches to the EOL Test mode.

After finalizing the EOL test, the EOL test equipment sends a special command to the device, that forces the device to write the information "EOL test is finished and passed" to the nvData. After next reset the firmware recognizes valid nvData containing the information about the passed EOL Test. The firmware branches to normal operation mode (Notice: re-programming the device via JTAG/SWD will not necessarily overwrite the nvData, but the programming procedure used right now will do so. That means all informations stored in nvData will be lost)

Updating via DFU does NOT overwrite the nvData. nvData is protected by the bootloader and can not be accessed via DFU!)

Procedure to skip the EOL Test:

After programming the firmware HEX file, a second HEX file needs to be programmed to the device. The second file does only contain the initial values of the nvData including the information about the passed EOL test (that actually was not performed!). After very first PON of the device the firmware then recognizes already valid nvData (containing the information about the EOL test) and switches to normal operation mode.

To ensure the integrity of the procedure following tests were made:

1. Program one device using the "standard" procedure (means only the firmware HEX file is programmed)
2. Read back the whole memory space and store it to a new HEX file (1)
3. Start the device, connect via UART, finalize the EOL test by sending the UART command
4. Read back the whole memory space and store it to a new HEX file (2)
→ Comparison of the two newly created hex files (1 and 2) must only differ in the magic number in nvData that finally disables the EOL test mode
5. Clear the whole flash memory of the device
6. Program the device using the "modified" procedure (means the firmware HEX file is programmed, the page containing the nvData is cleared, the HEX file containing the initial nvData is programmed)
7. Read back the whole memory space and store it into a new hex file (3)

8. Comparison of the hex files 2 and 3 must not have any differences (with except of the anchors offset calibration value)

→ Comparison passed on ball and anchor

The created hex files can be found here:

\\192.168.0.243\GIE_Work\GIE_Design_Archiv\Software_50x\505x_32Biter\505028_001_FW_Bowne_C4-Sample_Ball_240716\120_ohne_EOL\Tests

\\192.168.0.243\GIE_Work\GIE_Design_Archiv\Software_50x\505x_32Biter\505027_002_FW_Bowne_C5-Sample_Anchor_240716\56_ohne_EOL\Tests

8 Ball

Samples used for testing:

Bench Tests	
PCB Serial No.	100551 (C4)
FW Versions	104
Mechanics used	- unmounted PCB - Powered by external powersource @3,0V
Integration in Ball (Functional Tests):	
PCB Serial No.	100555 (C4) 95458 (C2.1) 95457 (C2.1) 95393 (C2.1) 95456 (C2.1) 95479 (C2.1)
FW Versions	104

Mechanics used	<ul style="list-style-type: none">- unmounted PCB- Powered by external powersource @3,0V- Printed prototype Housing with red Prototype Ball- Housing "Test Sample" with "Test Sample" BallOld PCB Sample C1 was replaced with sample C4- Used button cell battery: muRata CR2032 Lithium 3V
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8.1 Integration Test

8.1.1 Current consumption measurement

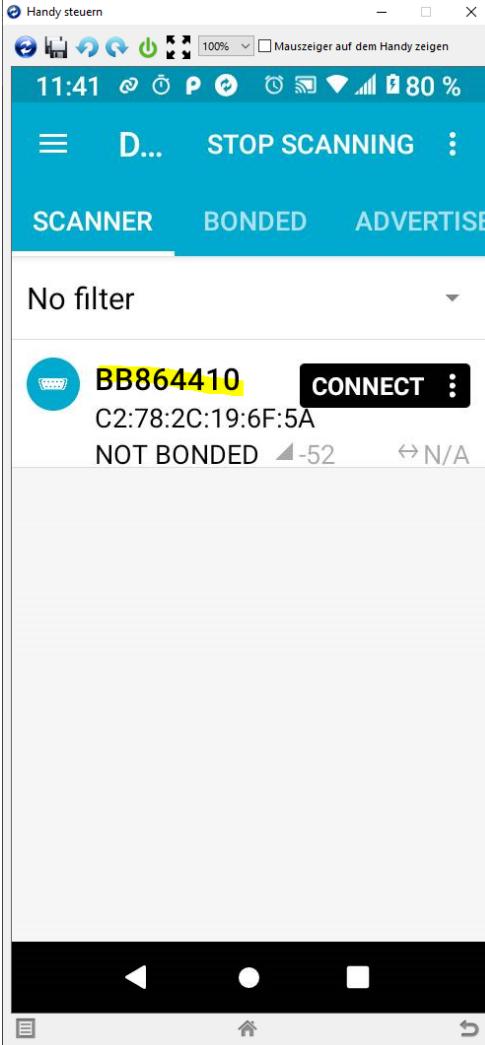
Current consumption is made on the test bench with external power supply @3,0V

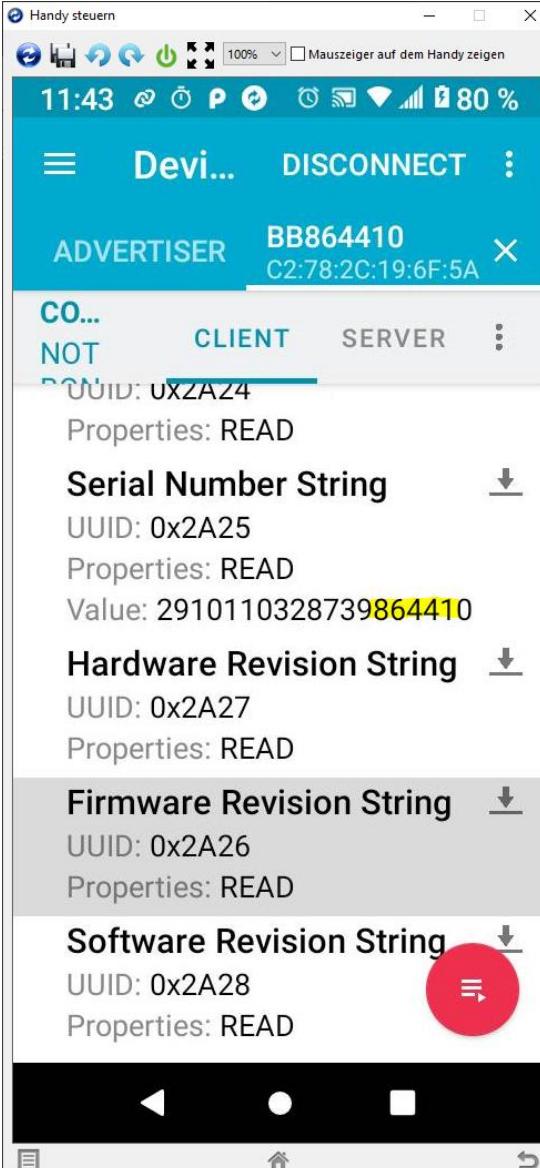
Teststep	4.1.1.1
Description	<p>Repower device after flashing/firmware update</p> <p>After repowering LED must flash green 1/second</p> <p>Check Power consumption</p> <p>Power consumption shall be 5.2 mA +- 0,2mA @ 3,0V</p>
Result/Deviation	<p>OK</p>  <p>5,243 mA</p>

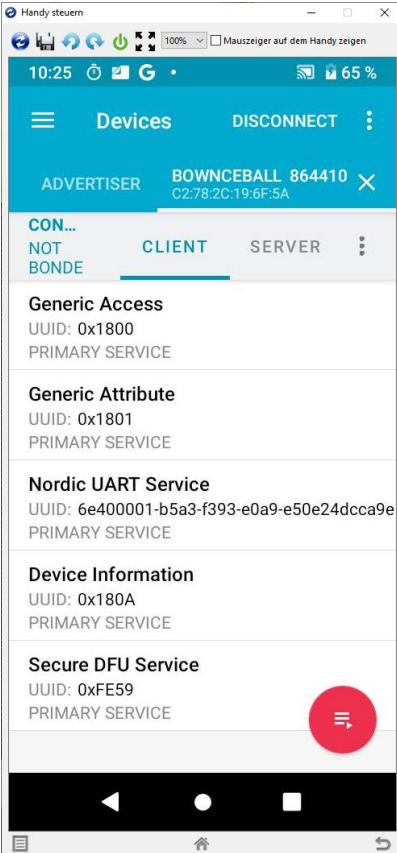
8.1.2 Off-Mode timer behaviour and Off-Mode current

Teststep	4.1.2.1
Description	<p>Wait until device goes into Off-Mode (3min +/- 2sec.) Even with active connection. Check Power consumption</p> <ul style="list-style-type: none">- Not moving device, start timer, measure +/- 3minutes until device goes into Off-Mode- Move device again, connect BLE + BLE Uart, start timer, measure +/- 3 min. until device disconnects and goes into Off-Mode- Start device again, start timer, leave device unmoved until about 2 min. expired, move device, verify that device does not go into Off-Mode after 3 min! Device shall go into Off-Mode after 3 min. after last significant motion- Power consumption shall be 16uA +- 2uA @ 3,0V
Result/Deviation	<p>OK (no connection) OK (connected) OK (reset 3 min. timer after device was moved)</p>
	 <p>0,016mA</p>

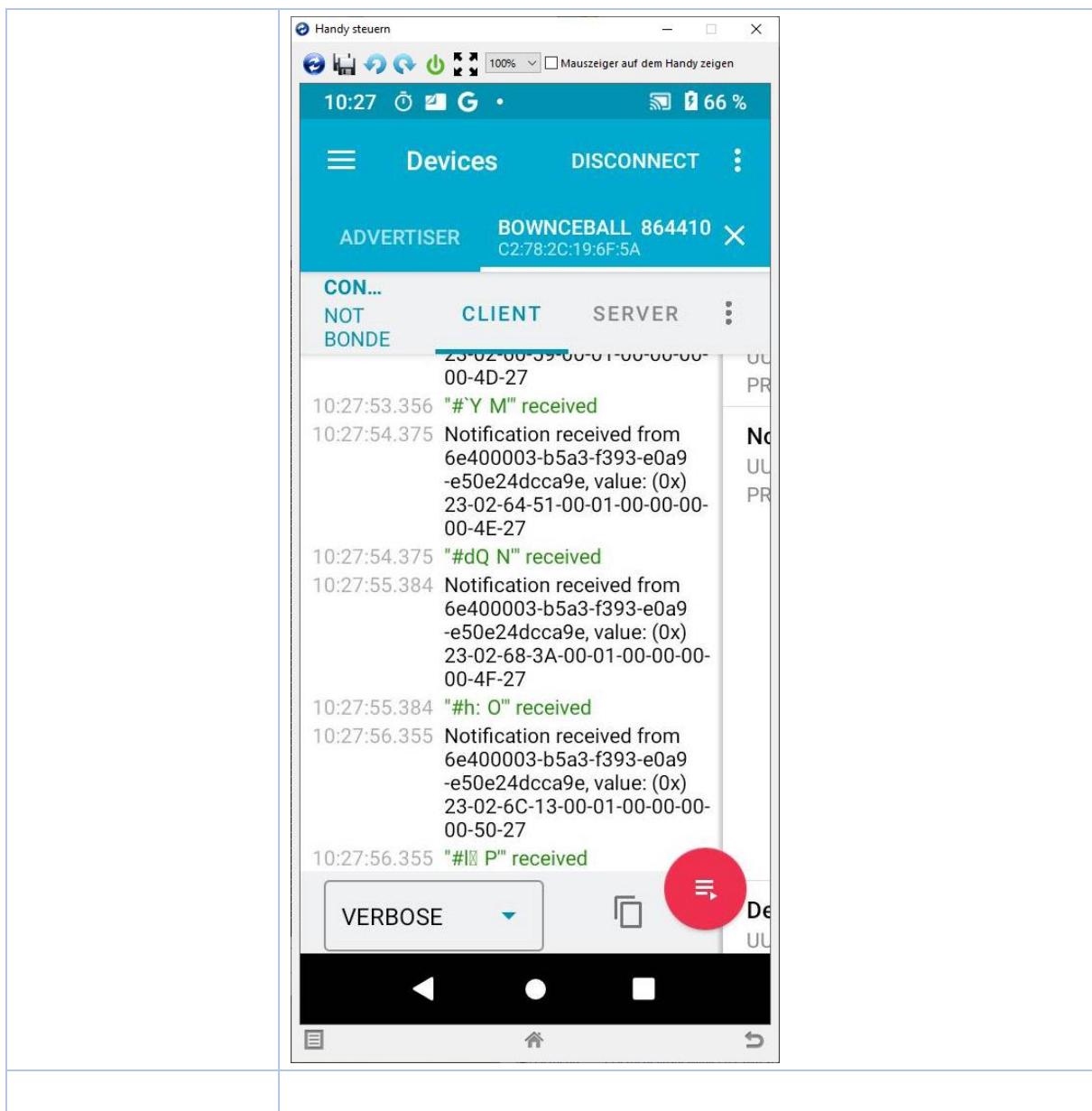
8.1.3 General BLE connection behaviour

Teststep	4.1.3.1
Description	Move device; Device must wake-up; LED must flash about 1/Second green. LED flash timing can vary, depending on load of the microcontroller. LED flashing has low priority!
Result/Deviation	OK
Teststep	4.1.3.2
Description	Scan the Device via Nordic nRF Connect App; Check the Device Name. Device name must start with 'BB' followed by 6 digits of the Controller UID
Result/Deviation	OK
	

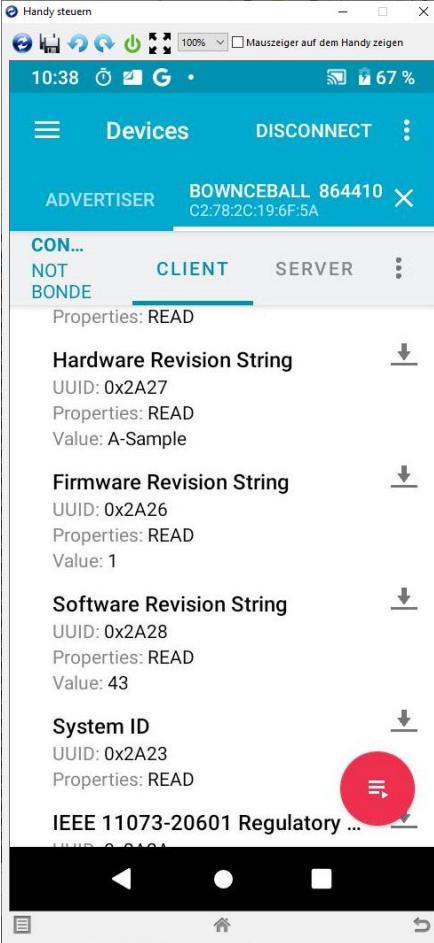
Teststep	4.1.3.5
Description	<p>Check the uC ID in DIS.</p> <p>Last 6 Digits of the ‘Serial Number String’ must correlate with the 6 Digits in the Device Name. See Teststep 4.1.3.2.</p>
Result/Deviation	<p>OK</p>  <p>The screenshot shows the Handy steuern application interface. At the top, it displays the device name "BB864410" and its MAC address "C2:78:2C:19:6F:5A". Below this, there are tabs for "ADVERTISER", "CLIENT", and "SERVER". Under the "CLIENT" tab, several service UUIDs are listed: "CO..." (NOT), "Serial Number String" (UUID: 0x2A25), "Hardware Revision String" (UUID: 0x2A27), "Firmware Revision String" (UUID: 0x2A26), and "Software Revision String" (UUID: 0x2A28). The "Serial Number String" value is highlighted in yellow as "2910110328739864410". A red circle with a white arrow points to the "Software Revision String" entry.</p>

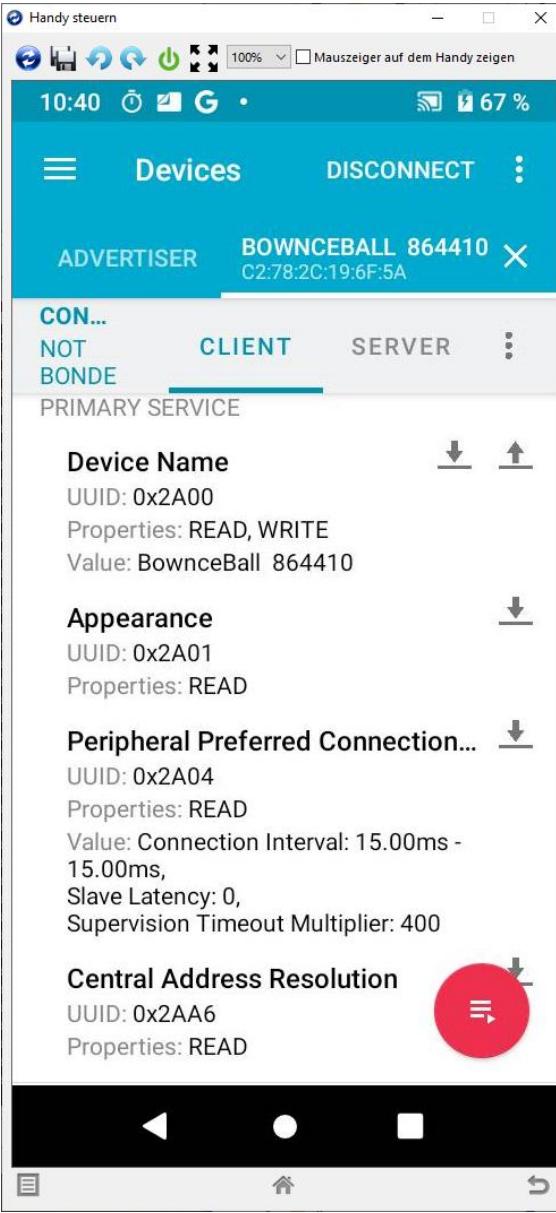
Teststep	4.1.3.6
Description	Connect to the Device via Nordic nRF Connect App; Check that the required services are available: Generic Access Generic Attribute Nordic UART Service Device Information Secure DFU Service
Result/Deviation	OK
	

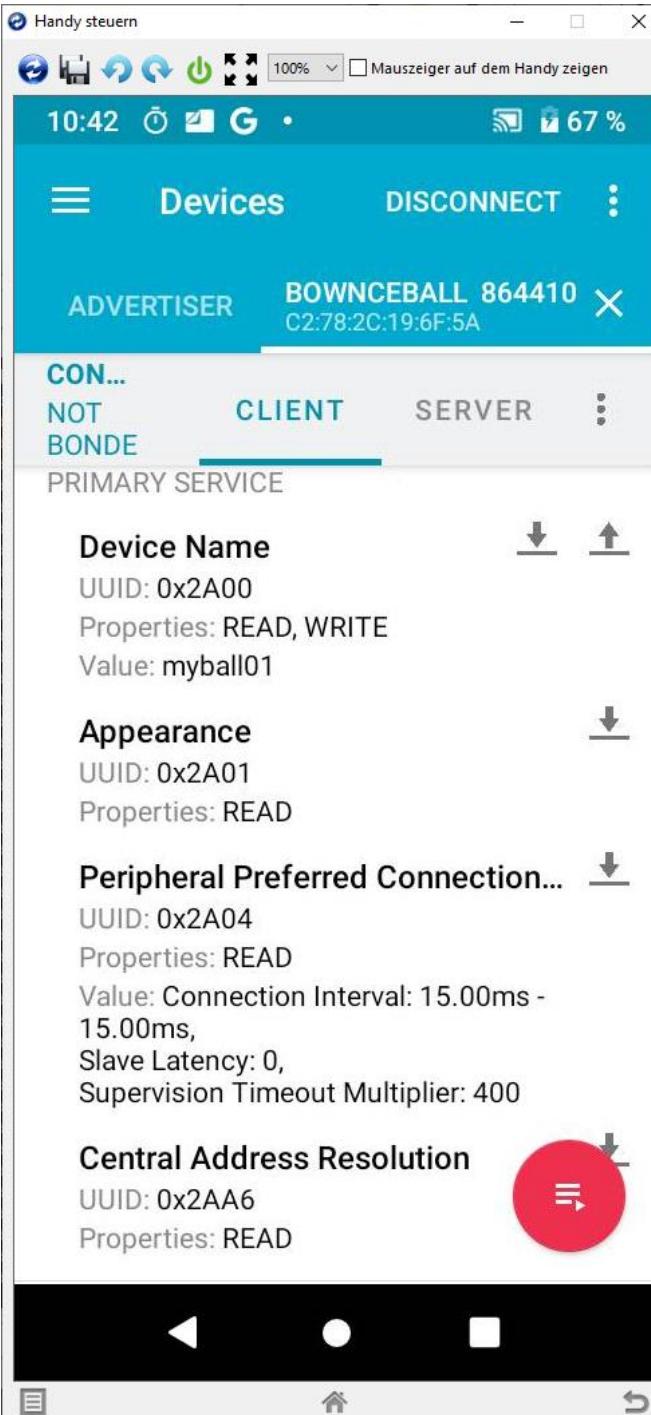
Teststep	4.1.3.7																																				
Description	<p>Connect to the UART Service via nRF Connect App; Check that there is a notification received every about 2 seconds</p> <p>Example:</p> <table border="1"> <thead> <tr> <th>Byte</th> <th>Example</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0x23</td> <td>SOF (Start of Frame)</td> </tr> <tr> <td>1-3</td> <td>0x02-0xF4-0x09</td> <td>Timestamp in [ms]</td> </tr> <tr> <td>4,5</td> <td>0x00-0x01</td> <td>Hitcounter</td> </tr> <tr> <td>6,7</td> <td>0x00-0x00</td> <td>Swingtime</td> </tr> <tr> <td>8</td> <td>0x00</td> <td>Consecutive hits</td> </tr> <tr> <td>9</td> <td>0x00</td> <td>Hit power</td> </tr> <tr> <td>10</td> <td>0x1D</td> <td>Battery level [V * 10]</td> </tr> <tr> <td>11</td> <td>0x04</td> <td>Accuracy (n.a.)</td> </tr> <tr> <td>12</td> <td>0x00</td> <td>Flags *)</td> </tr> <tr> <td>13</td> <td>0x25</td> <td>Transmission counter (0-255)</td> </tr> <tr> <td>14</td> <td>0x27</td> <td>EOF (End of Frame)</td> </tr> </tbody> </table> <p>*) See BLE UART protocol specification</p> <ol style="list-style-type: none"> 1. Check the Transmission counter for a couple of seconds and check that the counter is ascending without gaps 2. Check the Batteryvoltage (should be at 2,9 to 3,0 V with new Battery) 3. Force is implemented and must show numbers between 0 and 200 4. Consecutive Hits must count upwards; whenever a free swing is detected between two hits, the counter must stop counting. When hitting the ball again the counter must start counting with 1 and upwards 5. Hit the Ball and observe if the Hitcounter is counting 6. Check LED; must flash blue 7. Check Battery Voltage level 8. Leave it running with established connection for at least 3 minutes. Device must go into Off-Mode 9. Move the ball; Ball must wakeup; reconnect with NORDIC app) 	Byte	Example	Description	0	0x23	SOF (Start of Frame)	1-3	0x02-0xF4-0x09	Timestamp in [ms]	4,5	0x00-0x01	Hitcounter	6,7	0x00-0x00	Swingtime	8	0x00	Consecutive hits	9	0x00	Hit power	10	0x1D	Battery level [V * 10]	11	0x04	Accuracy (n.a.)	12	0x00	Flags *)	13	0x25	Transmission counter (0-255)	14	0x27	EOF (End of Frame)
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0	0x23	SOF (Start of Frame)																																			
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6,7	0x00-0x00	Swingtime																																			
8	0x00	Consecutive hits																																			
9	0x00	Hit power																																			
10	0x1D	Battery level [V * 10]																																			
11	0x04	Accuracy (n.a.)																																			
12	0x00	Flags *)																																			
13	0x25	Transmission counter (0-255)																																			
14	0x27	EOF (End of Frame)																																			
Result/Deviation	OK																																				

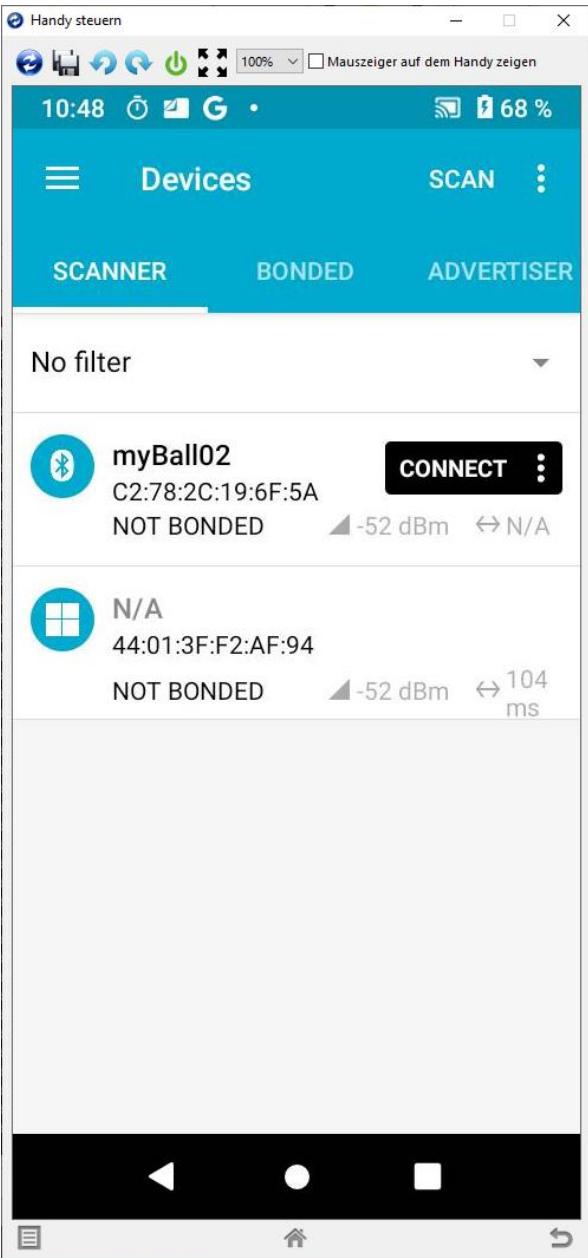


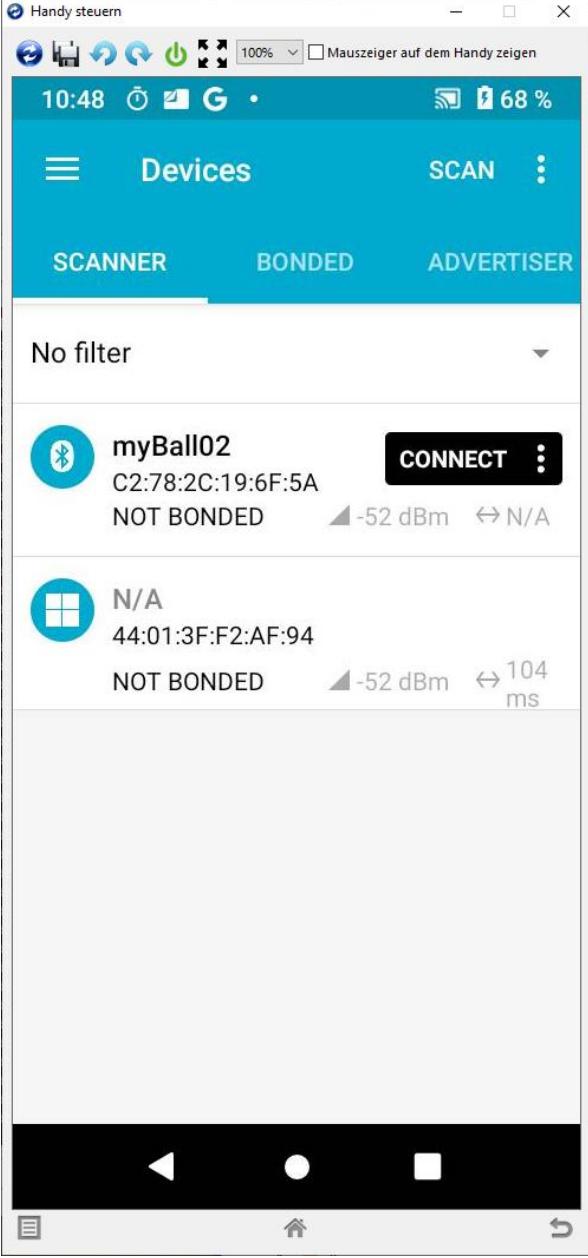
Teststep	4.1.3.8
Description	<p>Connect to the Device Information Service (DIS) via nRF Connect App; Read the “Software Revision String” and check that it represents the current Version number.</p> <p>(C1-Sample must send “C1-Sample” in Hardware Revision String)</p> <p>(C2.1 Sample must send “C2.1-Sample in Hardware Revision String)</p> <p>(C4 Sample must send “C4-Sample in Hardware Revision String)</p>
Result/Deviation	OK



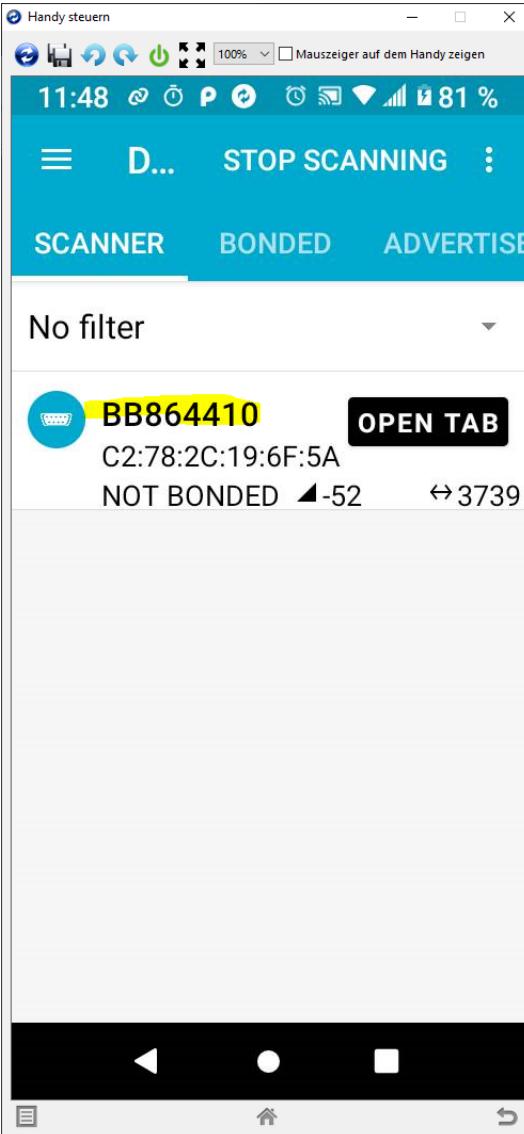
Teststep	4.1.3.9
Description	<p>Open the Tab “Generic Access Profile” GAP</p> <p>Read and check the device Name</p> <p>Read and check the “preferred connection”</p> <p>Must be 15ms/15ms/0/400</p>
Result/Deviation	OK
	

Teststep	4.1.3.10
Description	Change the device name and re-read it right after changing it. Check that the device name was properly changed
Result/Deviation	OK
	

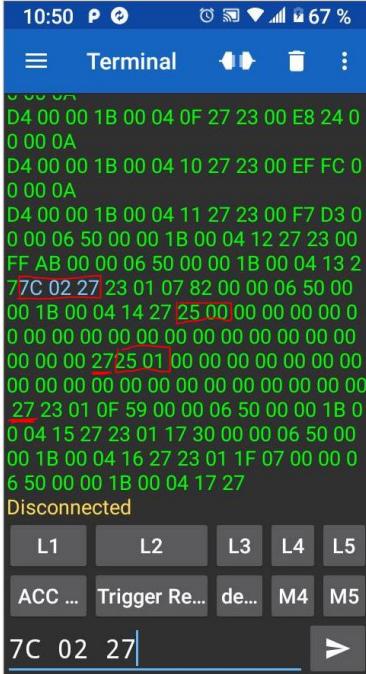
Teststep	4.1.3.11
Description	Disconnect from the device by pressing “Disconnect” in the nRF App Go back to the Scanner in the nRF App, and re-scann for the device Check that the device is now advertising with the new name (if the name was longer than 8 characters the name will be shortened to 8!)
Result/Deviation	OK
	

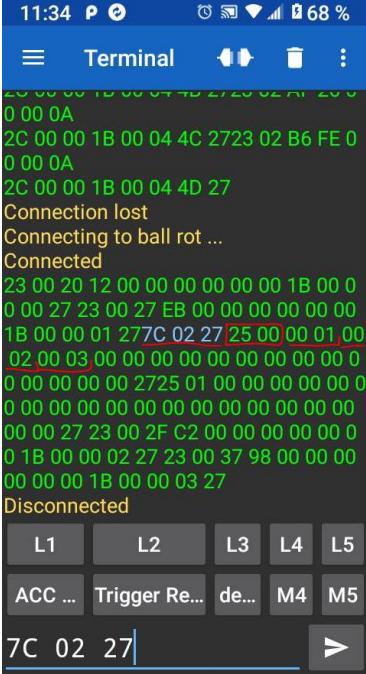
Teststep	4.1.3.12
Description	Repower the device by removing the battery. Re-scan for the device with the nRF App. Check that the device is still advertising with its new name
Result/Deviation	OK
	

8.1.4 Factory reset behaviour

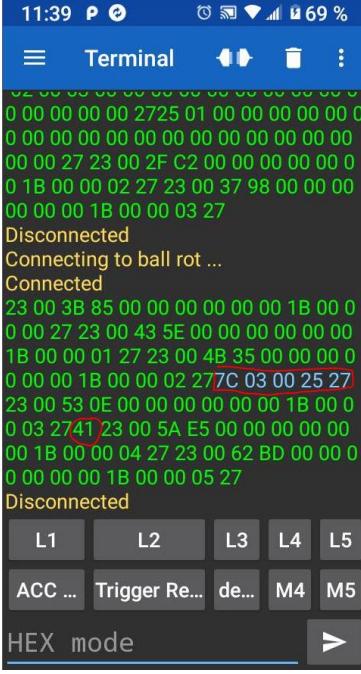
Teststep	4.1.4.1 (Factory Reset)
Description	Connect to the UART Service and send “3” (as character!) to device Disconnect the UART Service and repower the device The device must now advertise with the old name
Result/Deviation	OK - The Device name is cleared. The Device needs to be re-powered to load the default values from ROM. Without re-powering the device name in advertising is empty and the calibration values are invalid!
	

8.1.5 Offline bowncing (n.a.)

Teststep	13 Offline Bowncing
Precondition	Flash must be cleared! No sessions at all stored in the device. If the device flash is not cleared the test could also performed, but the description does not match then!
Description	Connect to the UART Service and Request offline session information (0x7C 0x02 0x27) Device must respond with session id list (session information frame 0 and 1)
Result/Deviation	n.a. from Version 2.18/99
	 <p>(No session stored at all)</p>

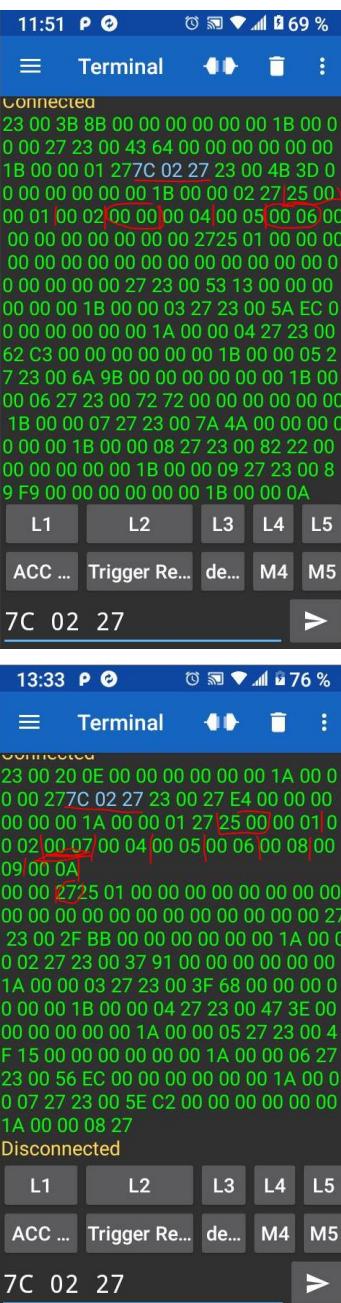
	 <p>11:34 P 68 %</p> <p>Terminal</p> <pre> 2C 00 00 1B 00 04 4C 2723 02 B6 FE 0 0 00 0A 2C 00 00 1B 00 04 4D 27 Connection lost Connecting to ball rot ... Connected 23 00 20 12 00 00 00 00 00 00 1B 00 0 0 00 27 23 00 27 EB 00 00 00 00 00 00 1B 00 00 01 277C 02 27 25 00 00 01,00 02 00 03 00 00 00 00 00 00 00 00 00 0 0 00 00 00 00 2725 01 00 00 00 00 00 0 0 00 00 00 00 00 00 00 00 00 00 00 00 00 00 27 23 00 2F C2 00 00 00 00 00 0 0 1B 00 00 02 27 23 00 37 98 00 00 00 00 00 00 1B 00 00 03 27 Disconnected L1 L2 L3 L4 L5 ACC ... Trigger Re... de... M4 M5 7C 02 27 > </pre> <p>(3 sessions stored)</p>

Teststep	14 Offline Bouncing – Request Session with wrong ID
Description	<p>Connect to the UART Service and Request offline session with wrong ID (0x27 0x03 ID ID 0x27)</p> <p>Wrong ID is a ID that is not included in the offline session information frame (see step #14)</p> <p>Device must respond with NACK (0x41)</p>
Result/Deviation	n.a. from Version 2.18/99

Teststep	14.1 Offline Bouncing – Request Session with correct ID
Description	Connect to the UART Service and Request offline session with wrong ID (0x27 0x03 ID ID 0x27) Device must respond with session Data frame
Result/Deviation	n.a. from Version 2.18/99
	

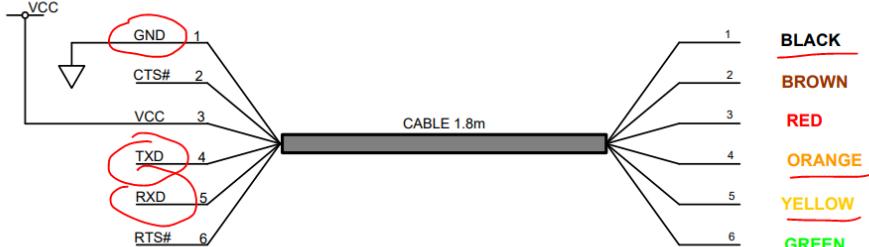
Teststep	15 Offline Bowing – Request Session list again
-----------------	-------------------------------------------------------

Description	<p>Connect to the UART Service and Request offline session information (see teststep #13) Device must respond with session information frame The requested Session must be deleted from the list Let the device go into off mode and restart again Repower, and request the session list again. The deleted session must be replaced with the next session (ID=6 in this example!)</p>
Result/Deviation	n.a. from Version 2.18/99
	 <p>The screenshots show the terminal application interface. The top screenshot is at 11:51 and the bottom one is at 13:33. Both show a list of session entries. In the top screenshot, session entry 6 is highlighted with red boxes around its ID and some of its data bytes. In the bottom screenshot, session entry 6 is no longer present, and session entry 7 has taken its place, also highlighted with red boxes.</p>

8.1.6 Bootloader behavior when battery power lost

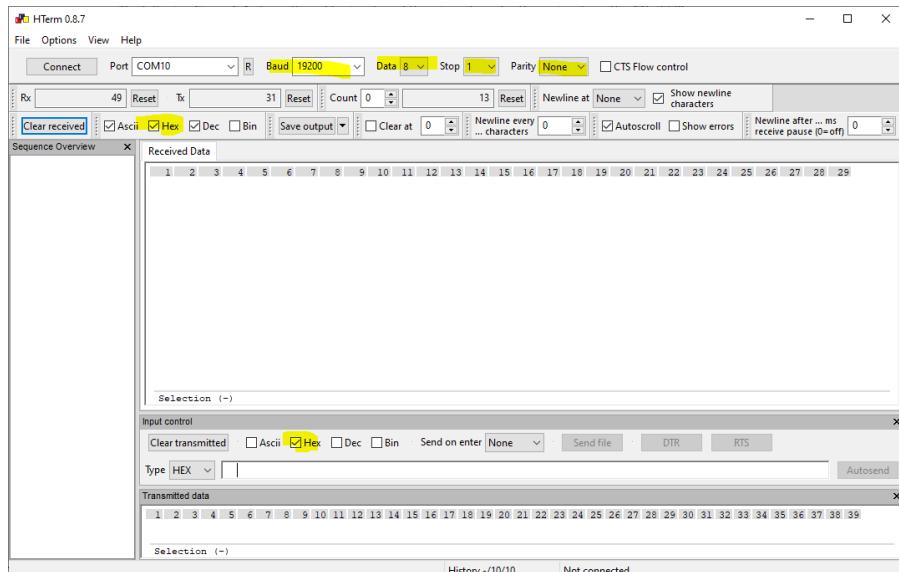
Teststep	4.1.6 Bootloader behavior when battery power lost
Description	Test the behaviour of the bootloader/application firmware when the bootloader update process gets interrupted by battery loss
Result/Deviation	<p>OK</p> <p>Ball is performing Dual-Bank-Update</p> <p>Beim Flashen einer Ball-Baugruppe wird auf dem Nordic App „nRF Tool Box“ ein prozentualer Status (von 1% bis 100%) für das Flashen-Vorgang angezeigt.</p> <p>Bei den Versuchen die Knopfzelle bei den Flash-Vorgängen 20%, 50% und 80% zu entfernen und wieder einsetzen, konnte folgendes festgestellt werden:</p> <ul style="list-style-type: none">1_Ball-Baugruppe blinkt grün (1 Hz in Sekunde)2_Beim Scannen mit Nordic App kann den ursprünglichen Namen gefunden werden (nicht BBBot)3_Ball lässt sich via Bluetooth verbinden und blinkt blau wie gewohnt4_UART Protokoll wird übertragen und beim Schlagen werden die Hits auch gezählt <p>das heißt, dass die Image die bereits auf dem uC geflasht wurde geht nicht defekt, wenn die Batterie während des Flashen entfernt wird.!</p> <p>C2.1 Muster: Die FW ist jetzt zu gross für dual bank update. D.h. der Bootloader macht einen “secure” single bank update. Wenn der Update fehlschlägt startet der Bootloader direct (BBBboot) und es kann wie gewohnt ein Update durchgeführt werden.</p>

8.1.7 EOL-UART protocol test

Teststep	4.1.6.1 EOL Uart Protokoll Test										
Description	<p>Test the EOL Uart Interface Connect the UART Interface via FTDI Cable (3V3)</p> <p>6.1 TTL-232R-5V-WE, TTL-232R-3V3-WE Connections and Mechanical Details</p> <p>The following Figure 6.1 shows the cable signals and the wire colours for these signals on the TTL-232R-5V-WE and TTL-232R-3V3-WE cables.</p> 										
<p>Figure 6.1 TTL-232R-5V-WE and TTL-232R-3V3-WE Connections</p>											
<p>Wiring, Testpins C2.1 Sample (FW Version 100)</p> <table border="1"> <thead> <tr> <th>Signalname</th> <th>Controller GPIO</th> <th>Function</th> </tr> </thead> <tbody> <tr> <td>BSP_EOL_UART_TX</td> <td>19*)</td> <td>Controller TxD</td> </tr> <tr> <td>BSP_EOL_UART_RX</td> <td>23*)</td> <td>Controller RxD</td> </tr> </tbody> </table>			Signalname	Controller GPIO	Function	BSP_EOL_UART_TX	19*)	Controller TxD	BSP_EOL_UART_RX	23*)	Controller RxD
Signalname	Controller GPIO	Function									
BSP_EOL_UART_TX	19*)	Controller TxD									
BSP_EOL_UART_RX	23*)	Controller RxD									
<p>*) Controller IO Ports, wiring solder direct to the controller pins, since no testpads available on HW Revision C2.1</p>											
<p>Wiring, Testpins C4 Sample (FW Version 104)</p> <table border="1"> <thead> <tr> <th>Signalname</th> <th>Testpad on PCB</th> <th>Function</th> </tr> </thead> <tbody> <tr> <td>BSP_EOL_UART_TX</td> <td>XP209 (FTDI-gelb)</td> <td>Controller TxD</td> </tr> <tr> <td>BSP_EOL_UART_RX</td> <td>XP206 (FTDI-orange)</td> <td>Controller RxD</td> </tr> </tbody> </table>			Signalname	Testpad on PCB	Function	BSP_EOL_UART_TX	XP209 (FTDI-gelb)	Controller TxD	BSP_EOL_UART_RX	XP206 (FTDI-orange)	Controller RxD
Signalname	Testpad on PCB	Function									
BSP_EOL_UART_TX	XP209 (FTDI-gelb)	Controller TxD									
BSP_EOL_UART_RX	XP206 (FTDI-orange)	Controller RxD									
<p>UART Commands:</p> <table border="1"> <thead> <tr> <th>Command</th> <th>Description</th> <th>Response</th> </tr> </thead> <tbody> <tr> <td>0x01</td> <td>UART_CMD_GOTO_SLEEP</td> <td>No Response. Device goes into Off-Mode immediately</td> </tr> <tr> <td>0x02</td> <td>UART_CMD_BMI270_SELFTEST</td> <td>Device performs BMI270 Selftest for acceleration and gyro.</td> </tr> </tbody> </table>			Command	Description	Response	0x01	UART_CMD_GOTO_SLEEP	No Response. Device goes into Off-Mode immediately	0x02	UART_CMD_BMI270_SELFTEST	Device performs BMI270 Selftest for acceleration and gyro.
Command	Description	Response									
0x01	UART_CMD_GOTO_SLEEP	No Response. Device goes into Off-Mode immediately									
0x02	UART_CMD_BMI270_SELFTEST	Device performs BMI270 Selftest for acceleration and gyro.									

		Response 0x00 → Test passed Response 0x01 → Test failed
0x03	UART_CMD_GET_FW_VERSION	Device responds with FW Version (104)
0x04	UART_CMD_GET_UID	Device responds with 8 Digit Controller UID
0x05	UART_CMD_ADXL_SELFTEST	Device performs ADXL Selftest. Response 0x00 → Test passed Response 0x01 → Test failed
0x09	UARTS_CMD_FINAL_DISABLE	Finally disable the EOL Test. No response

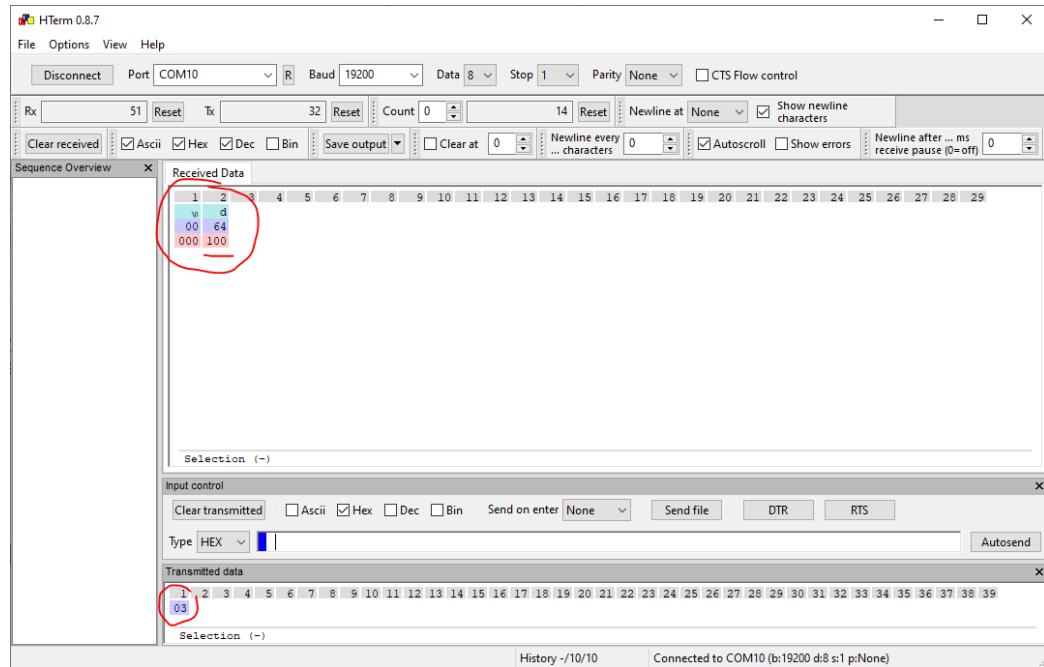
Terminal settings:



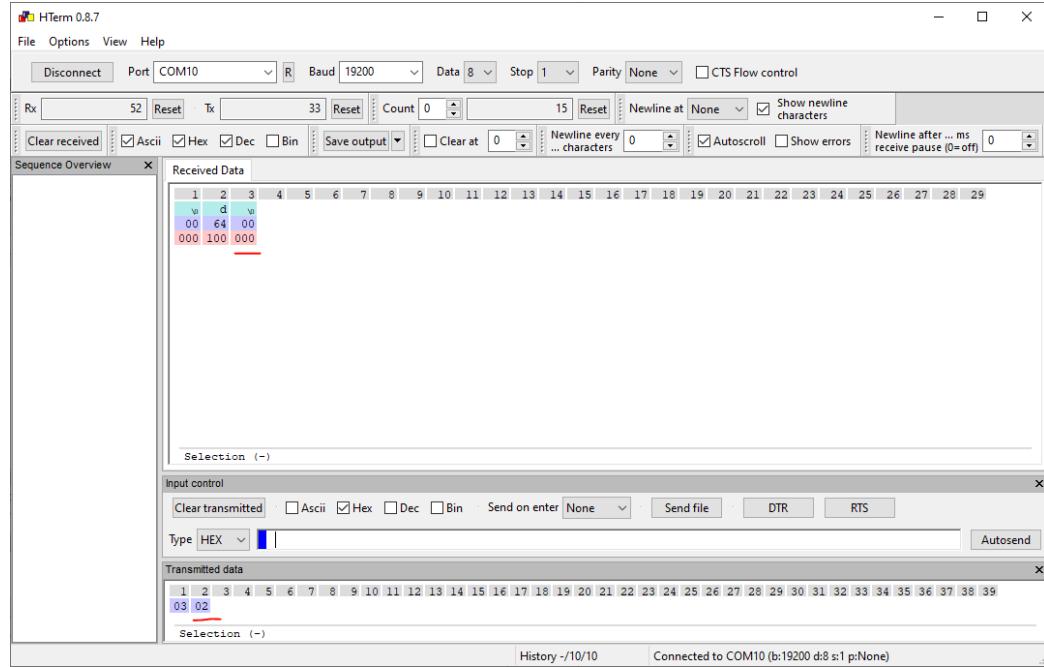
Use HTerm for testing, because HTerm is able to send/receive HEX values. With other (ASCII) Terminals it is necessary to calculate ASCII Values!

Result/Deviation	OK
-------------------------	----

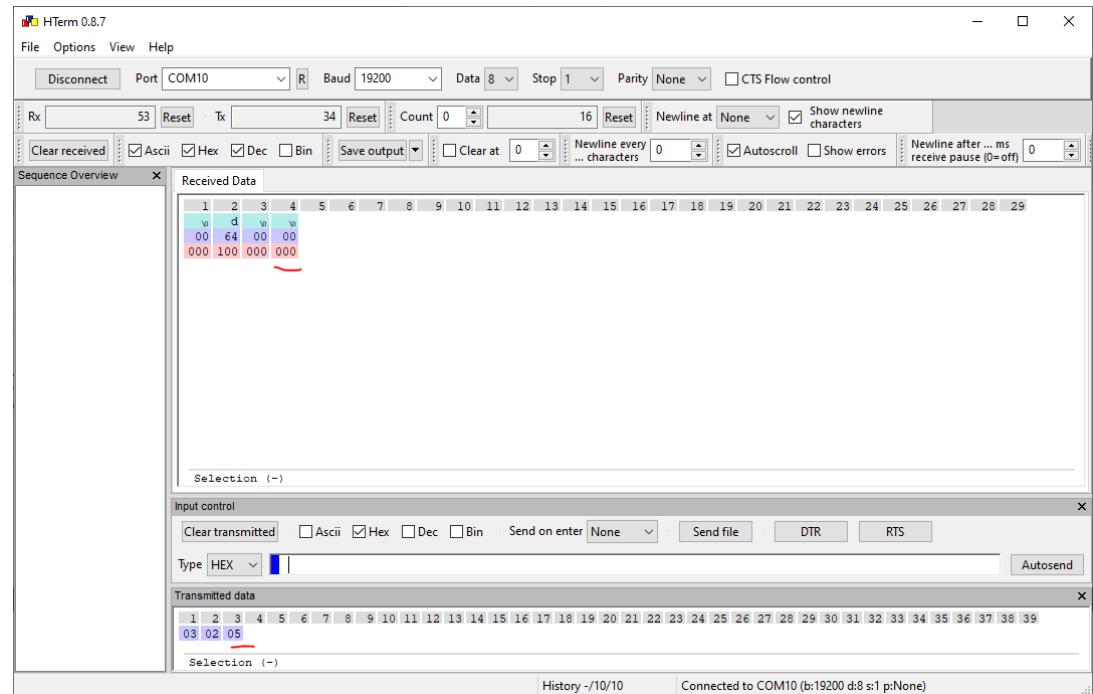
4.1.6.2: UART_CMD_GET_FW_VERSION



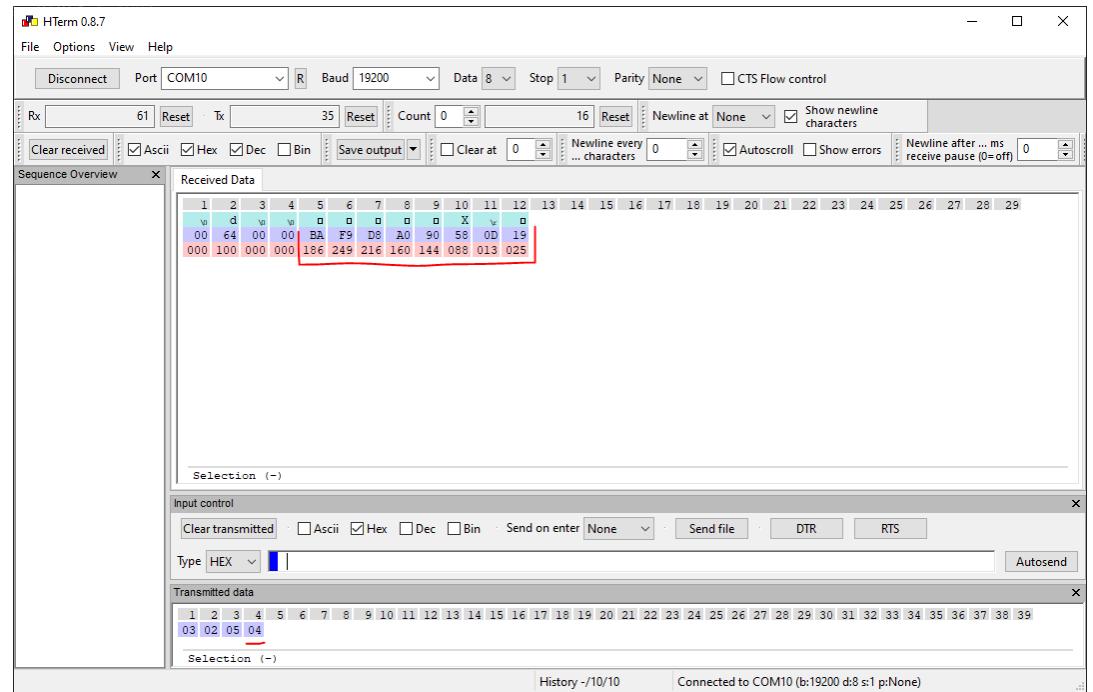
4.1.6.3: UART_CMD_BMI270_SELFTEST



4.1.6.4: UART_CMD_AXDL_SELFTEST



4.1.6.5: UART_CMD_GET_UID



4.1.6.6: UART_CMD_GOTO_SLEEP

No response from device. Instead of response device goes into Off-Mode immediately after receiving the command. Check power consumption.

Result : 14 uA

(UART Interface has to be disconnected after device went into Off-Mode. Do not shake the device when disconnecting the UART Interface)

With connected Interface the power consumption is not realistic because of pull up resistors inside the Interface!)

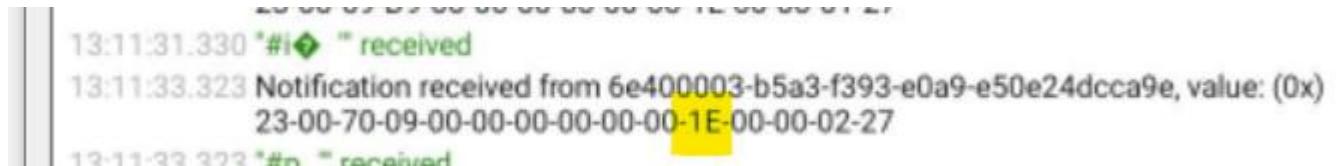
8.2 Functional Test

8.2.1 Battery voltage monitoring

Test: check if battery voltage monitoring in the ball correlates with “real” battery voltage

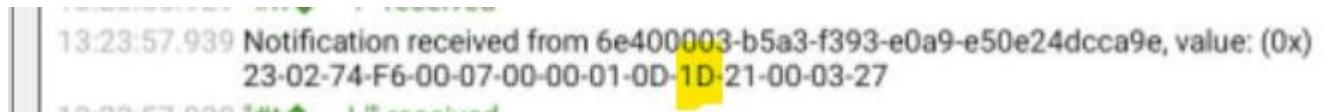
Test was done with FW Version 100

1. Battery was disassembled from battery tray. Voltage measured : 3,2721V
2. Battery assembled with ball. Ball starts advertising
3. Connect Ball with nFR App and request data frames via BLE UART profile
4. Ball transmits battery voltage 0x1E → 3,0V
5. Deviation accepted because of voltage drop thru power consumption during data transmission



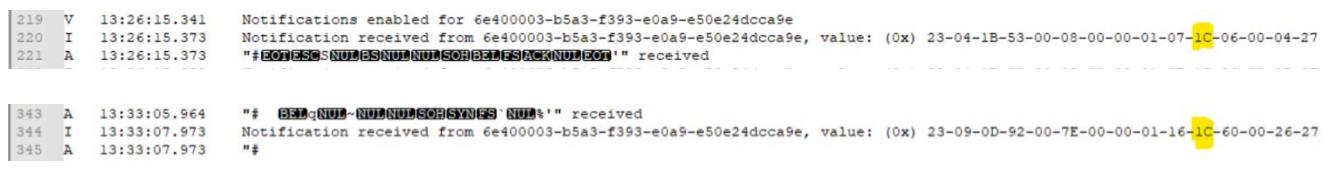
13:11:31.330 *#i \blacktriangleleft " received
13:11:33.323 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x) 23-00-70-09-00-00-00-00-00-00-1E-00-00-02-27
13:11:33.323 *#i \blacktriangleleft " received

6. Ball went to Off-Mode
7. Ball woke up again



13:23:57.939 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x) 23-02-74-F6-00-07-00-00-01-0D-1D-21-00-03-27
13:23:57.939 *#i \blacktriangleleft " received

8. Ball transmits battery voltage 0x1D → 2,9V
9. Deviation accepted because of voltage drop thru power consumption during data transmission
10. Observe battery voltage monitoring during realistic bowncing session
11. Voltage drop to 2,8V monitored 0x1Ch -> 28 dec -> 2,8V



219 V 13:26:15.341 Notifications enabled for 6e400003-b5a3-f393-e0a9-e50e24dcca9e
220 I 13:26:15.373 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x) 23-04-1B-53-00-08-00-00-01-07-1C-06-00-04-27
221 A 13:26:15.373 "#ESCqNUB-NULNULSOHSYNF\$'NU%'" received

343 A 13:33:05.964 "# ESCqNUB-NULNULSOHSYNF\$'NU%'" received
344 I 13:33:07.973 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x) 23-09-0D-92-00-7E-00-00-01-16-1C-60-00-26-27
345 A 13:33:07.973 "#

12. See Appendix A
13. Ball went to Off-Mode after inactivity
14. Ball went to On-Mode after single hit
15. After reconnect with nRF App and request of data transmission ball responds with battery voltage monitoring

14:09:56.694 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x)
23-00-6F-0F-00-00-00-00-00-1C-00-00-00-27

16. Voltage monitoring 0x1Ch -> 28 dec -> 2,8V

14:22:06.879 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x)
23-01-60-E2-00-00-00-00-00-1B-00-00-00-27

14:22:06.880 "# ⚡ " received

14:43:04.779 "# ⚡ W " received

14:43:06.773 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x)
23-01-AF-73-00-00-00-00-00-1B-00-00-02-27

14:43:06.773 "# ⚡ s " received

14:43:08.551 Disabling notifications for 6e400003-b5a3-f393-e0a9-e50e24dcca9e
" received

16:25:58.768 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x)
23-03-A5-03-00-0F-00-00-01-11-1A-89-00-0B-27

16:25:58.768 "# ⚡ ⚡ " received

17. Voltage monitoring 0x1Bh -> 27 dec -> 2,7V / 0x1Ah -> 26 dec -> 2,6V

18. Battery disassembled and voltage measured 2,8752 V. Deviation accepted because of voltage drop when loaded!

19. Batterie monitoring after 24h of inactivity (Off-Mode)

23-00-A0-49-00-00-00-00-00-00-1B-00-00-00-27

08:17:21.816 "# ⚡ I " received

08:17:23.811 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x)
23-00-A6-6E-00-00-00-00-00-1B-00-00-01-27

08:17:23.811 "# ⚡ n " received

08:17:24.691 Disabling notifications for 6e400003-b5a3-f393-e0a9-e50e24dcca9e

13:59:51.940 "# o. " received

13:59:53.934 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x)
23-01-75-4A-00-00-00-00-00-1A-00-00-02-27

13:59:53.935 "# uJ " received

```
16:32:28.161 "#," received
16:32:30.156 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x)
23-00-E2-D2-00-00-00-00-00-00-1A-00-00-02-27
16:32:30.156 "#◆◆" received
16:32:32.151 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x)
```

```
23-04-CC-9F-00-9A-00-00-01-1D-1A-6D-00-3F-27
18:04:55.536 "#,◆ m?" received
18:04:57.545 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x)
23-04-D2-B7-00-9A-00-00-01-1D-1A-6D-00-40-27
18:04:57.545 "# ◆ m@" received
```

20. Batterie monitoring after 24h of inactivity (Off-Mode)

```
09:05:38.930 "#\x" received
09:05:40.923 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x)
23-00-62-99-00-00-00-00-00-1A-00-00-02-27
09:05:40.923 "#b◆" received

10:39:28.653 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x)
23-00-A8-B2-00-2F-00-00-01-07-1A-89-00-03-27
10:39:28.653 "#◆◆/ ◆" received
```

```
Z3-UU-50-ZU-UU-U-U-UU-UU-U-U-A-4B-UU-UZ-Z/
14:59:58.626 "#V K" received
15:00:00.622 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x)
23-00-5C-3D-00-01-00-00-00-07-1A-4B-00-03-27
15:00:00.622 "#\= K" received
15:00:01.813 Data written to descr. 00002902-0000-1000-8000-00805f9b34fb. value: (0x) 00-00
```

21. Batterie monitoring after 72h of inactivity (Off-Mode) → Batterie empty

22. Batterie replaced. Voltage measured 3,1V (disassembled)

09:33:30.692 "#QN" received
09:33:32.701 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x)
23-00-57-86-00-00-00-00-00-1E-00-00-01-27
09:33:32.702 "#W◆" received
09:33:34.697 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x)
23-00-5D-BD-00-00-00-00-00-10-00-00-02-27
09:33:34.697 "#]◆" received
09:33:34.707 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x)

0x1Dh = 1 * 16 + 13 * 1 = 29 -> 2,9 V

11:08:32.311 "#◆" received
11:08:32.311 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x)
23-00-FE-30-00-06-00-00-01-10-1A-0F-00-04-27
11:08:32.311 "#◆0" received

0x1A = 16 + 10 = 26 -> 2,6V

11:54:16.604 Notifications enabled for 6e400003-b5a3-f393-e0a9-e50e24dcca9e
11:54:16.617 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x)
23-02-CF-AB-00-F0-00-00-01-08-1A-AD-00-00-27
11:54:16.617 "#x◆◆" received
11:54:18.255 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x)
23-02-D4-C4-00-F0-00-00-01-08-1A-AD-00-01-27
11:54:18.256 "#◆◆◆◆◆" received

16:42:09.888 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x)
23-00-74-DD-00-1A-00-00-01-0A-1A-16-00-02-27
16:42:09.888 "#1◆"
enabled

23. Batterie monitoring after 24h of inactivity (Off-Mode)

09:15:11.567 "# ?\$" received
09:15:13.555 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x)
23-01-45-44-00-00-00-00-00-1A-00-00-01-27
09:15:13.555 "# ED" received
09:15:14.126 Dieahlinn notifications for 6e400003-b5a3-f393-e0a9-e50e24dcca9e

24. Batterie monitoring after 24h of inactivity (Off-Mode)

14:18:36.121 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x)
23-00-E2-99-00-00-00-00-00-1A-00-00-00-27
14:18:36.121 "#◆" received

0x1ah -> 2,6 V Spannung

Conclusion:

Testdescription	FW	Result
Batterie voltage monitoring	100/101 (FW updated on test sample during test)	OK

8.2.2 General BLE connect / disconnect behaviour

1. Ball was in Off-Mode, tried to connect via nRF Connect App
2. No connection could be established

```
14:19:18.218 gatt.close()
14:19:18.227 wait(200)
14:19:18.428 Connecting to DD:D0:58:87:09:77...
14:19:18.428 gatt = device.connectGatt(autoConnect = false, TRANSPORT_LE, preferred PHY = LE 1M)
14:19:23.484 [Callback] Connection state changed with status: 133 and new state: DISCONNECTED (0)
14:19:23.484 Error 133 (0x85): GATT ERROR
14:19:23.484 Disconnected
```

3. Ball was hit and moved by hand. LED started to flash green. Ball woke up
4. Ball was connectable after 3. Attempt. Result accepted, first connection can take some more time since devices negotiate connection parameters for the first time!
5. Manual activation of Nordic UART profile
6. Ball starts to transmit data frames

```
14:22:06.879 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x)
23-01-60-E2-00-00-00-00-00-1B-00-00-00-27
14:22:06.880 "# ` " received
```

7. Data transmitted according to specification
8. Ball left untouched. Ball went to Off-Mode
9. nRF Connect App responds with GATT CONN TIMEOUT, since connection was closed by the ball

```
14:22:11.618 "Notifications and indications disabled" sent
14:22:11.621 Notifications and indications disabled for 6e400003-b5a3-f393-e0a9-e50e24dcca9e
14:23:20.723 [Callback] Connection state changed with status: 8 and new state: DISCONNECTED (0)
14:23:20.724 Error 8 (0x8): GATT CONN TIMEOUT
14:23:20.724 Disconnected
14:23:20.835 [Broadcast] Action received: android.bluetooth.device.action.ACL_DISCONNECTED
```

10. Ball woke up by movement
11. Reconnect tot he ball via nRF Connect
12. Wait until ball went to Off-Mode
13. Time until ball went to Off-Mode ca. 3 Min.

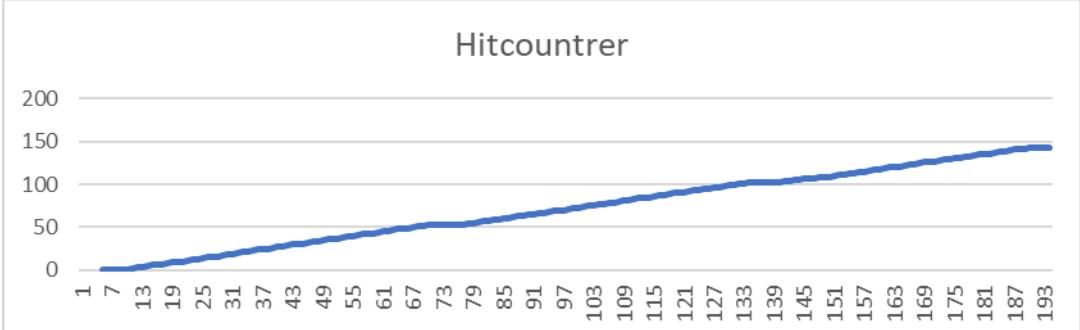
```
10:16:59.734 Disconnected
10:17:15.348 Error 133 (0x85): GATT ERROR
10:17:15.348 Disconnected
10:17:15.687 Connected to DD:D0:5B:87:09:77
10:17:15.993 Connection parameters updated (interval: 7.5ms, latency: 0, timeout: 5000ms)
10:17:16.293 Services discovered
10:17:16.354 Connection parameters updated (interval: 45.0ms, latency: 0, timeout: 5000ms)
10:17:20.671 Connection parameters updated (interval: 15.0ms, latency: 0, timeout: 4000ms)
10:17:27.288 Data written to descr. 00002902-0000-1000-8000-00805f9b34fb, value: (0x) 01-00
10:17:27.289 "Notifications enabled" sent
10:17:28.834 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x)
23-00-3D-95-00-00-00-00-00-1A-00-00-00-27
10:17:28.834 "#=◆" received
10:17:30.828 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x)
23-00-43-B0-00-00-00-00-00-1A-00-00-01-27
10:17:30.828 "#C◆" received
10:17:32.840 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x)
23-00-49-CC-00-00-00-00-00-1A-00-00-02-27
10:17:32.840 "#I◆" received
10:17:34.834 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x)
23-00-4F-E9-00-00-00-00-00-1A-00-00-03-27
10:17:34.834 "#O◆" received
10:17:36.829 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x)
23-00-56-06-00-00-00-00-00-1A-00-00-04-27
10:17:36.829 "#V" received
10:17:38.838 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x)
23-00-5C-23-00-00-00-00-00-1A-00-00-05-27
10:17:38.838 "#\#" received
10:17:40.834 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x)
23-00-62-3E-00-00-00-00-00-1A-00-00-06-27
10:17:40.834 "#b>" received
10:17:42.829 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x)
23-00-68-5A-00-00-00-00-00-1A-00-00-07-27
10:17:42.829 "#hZ" received
10:17:44.838 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x)
23-00-6E-76-00-00-00-00-00-1A-00-00-08-27
10:17:44.838 "#nv" received
10:17:46.834 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x)
23-00-74-92-00-00-00-00-00-1A-00-00-09-27
10:17:46.834 "#t◆" received
10:17:48.774 Data written to descr. 00002902-0000-1000-8000-00805f9b34fb, value: (0x) 00-00
10:17:48.774 "Notifications and indications disabled" sent
10:19:58.878 Data written to descr. 00002902-0000-1000-8000-00805f9b34fb, value: (0x) 01-00
10:19:58.878 "Notifications enabled" sent
10:19:59.838 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x)
23-02-0A-7E-00-00-00-00-19-00-00-0A-27
10:19:59.838 "#"
    ~
    " received
```

```
10:19:59.838 "#  
~  
" received  
10:20:01.848 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x)  
23-02-10-99-00-00-00-00-19-00-00-0B-27  
10:20:01.848 "# ◆ " received  
10:20:03.844 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x)  
23-02-16-B3-00-00-00-00-19-00-00-0C-27  
10:20:03.844 "# ◆ " received  
10:20:05.839 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x)  
23-02-1C-CF-00-00-00-00-19-00-00-0D-27  
10:20:05.839 "# ◆ " received  
10:20:07.849 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x)  
23-02-22-E9-00-00-00-00-19-00-00-0E-27  
10:20:07.849 "# ◆ " received  
10:20:15.657 Error 8 (0x8): GATT CONN TIMEOUT  
10:20:15.657 Disconnected  
10:24:33.264 Connected to DD:D0:58:87:09:77  
10:24:33.617 Connection parameters updated (interval: 7.5ms, latency: 0, timeout: 5000ms)  
10:24:33.930 Services discovered  
10:24:33.978 Connection parameters updated (interval: 45.0ms, latency: 0, timeout: 5000ms)  
10:24:38.477 Connection parameters updated (interval: 15.0ms, latency: 0, timeout: 4000ms)
```

Conclusion:

Testdescription	FW	Result
BLE connect/disconnect behaviour	100	OK

8.2.3 Hitcounter behaviour

Teststep	4.2.3.1 Hitcounter incrementation																																																																				
Precondition	Rope tension must be in valid range (1Kg – 2Kg)																																																																				
Description	<p>Connect the Ball to the BLE Central Datalogger. Make sure the Ball is the one and only device in range that is advertising. Datalogger will connect to the first device which could be found!)</p> <p>Connect the Datalogger to Terminal</p> <p>(Description of Datalogger see Appendix B:</p> <p>Log Data via Datalogger while bowncing. Try to count your hits. E.g. try to count up to 10 hits, 5 times, stop bowncing. Check if hitcounter has increased by 50 hits. Repeat procedure, Repeat with different rope tensions</p>																																																																				
Result/Deviation	OK																																																																				
	 <p>The graph shows a linear increase in the hitcounter value over time. The x-axis is labeled with sample numbers from 1 to 193. The y-axis ranges from 0 to 200. The data points form a straight line starting at (1, 0) and ending at (193, 145).</p> <table border="1"><caption>Data points estimated from the Hitcounter graph</caption><thead><tr><th>Sample</th><th>Hitcounter Value</th></tr></thead><tbody><tr><td>1</td><td>0</td></tr><tr><td>7</td><td>5</td></tr><tr><td>13</td><td>10</td></tr><tr><td>19</td><td>15</td></tr><tr><td>25</td><td>20</td></tr><tr><td>31</td><td>25</td></tr><tr><td>37</td><td>30</td></tr><tr><td>43</td><td>35</td></tr><tr><td>49</td><td>40</td></tr><tr><td>55</td><td>45</td></tr><tr><td>61</td><td>50</td></tr><tr><td>67</td><td>55</td></tr><tr><td>73</td><td>60</td></tr><tr><td>79</td><td>65</td></tr><tr><td>85</td><td>70</td></tr><tr><td>91</td><td>75</td></tr><tr><td>97</td><td>80</td></tr><tr><td>103</td><td>85</td></tr><tr><td>109</td><td>90</td></tr><tr><td>115</td><td>95</td></tr><tr><td>121</td><td>100</td></tr><tr><td>127</td><td>105</td></tr><tr><td>133</td><td>110</td></tr><tr><td>139</td><td>115</td></tr><tr><td>145</td><td>120</td></tr><tr><td>151</td><td>125</td></tr><tr><td>157</td><td>130</td></tr><tr><td>163</td><td>135</td></tr><tr><td>169</td><td>140</td></tr><tr><td>175</td><td>142</td></tr><tr><td>181</td><td>144</td></tr><tr><td>187</td><td>146</td></tr><tr><td>193</td><td>148</td></tr></tbody></table>	Sample	Hitcounter Value	1	0	7	5	13	10	19	15	25	20	31	25	37	30	43	35	49	40	55	45	61	50	67	55	73	60	79	65	85	70	91	75	97	80	103	85	109	90	115	95	121	100	127	105	133	110	139	115	145	120	151	125	157	130	163	135	169	140	175	142	181	144	187	146	193	148
Sample	Hitcounter Value																																																																				
1	0																																																																				
7	5																																																																				
13	10																																																																				
19	15																																																																				
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157	130																																																																				
163	135																																																																				
169	140																																																																				
175	142																																																																				
181	144																																																																				
187	146																																																																				
193	148																																																																				

8.2.4 BLE stability endurance test

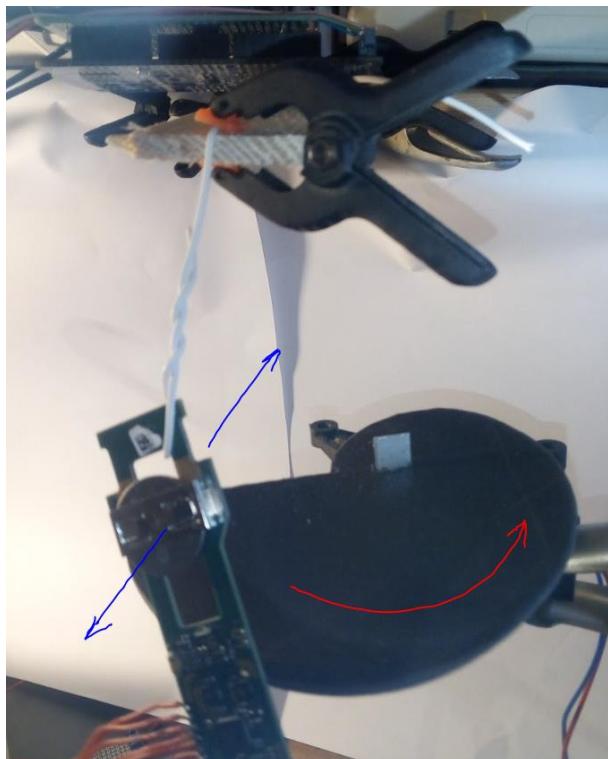
Preface:

To ensure the stability of the Bluetooth connection a endurance test shall be performed. The ball device shall run at least 24 hours without going into power-off mode. During this 24h the device shall be connected to a BLE „central“ device and thransfer it's data package to the central. There must be no disconnect event during the test.

To ensure the device stays in power-on mode the device must be moved arround permanently.

As the „central“ the GIE BLE Datalogger is used. See Appendix B.

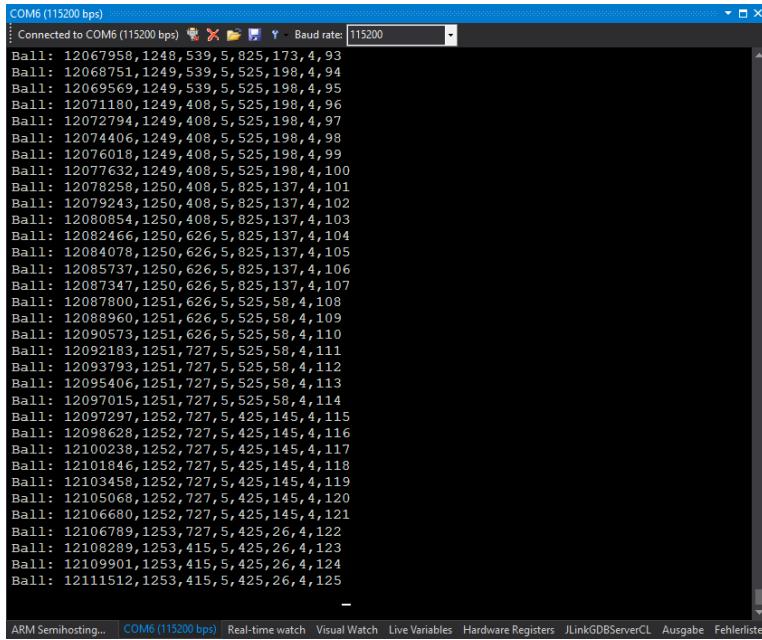
The device is keep moving by a dc motor with simple mechanics:



While the plate is rotating the device is moving back and forth.

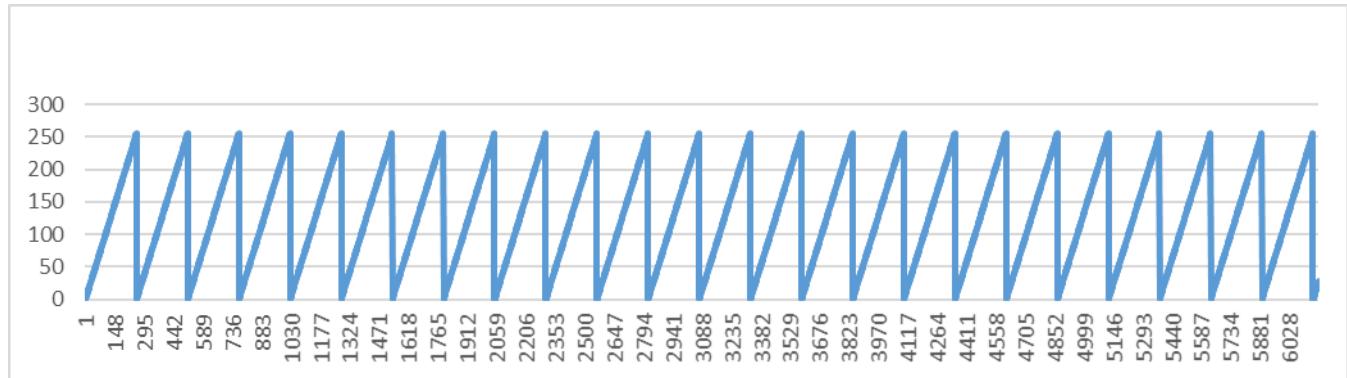
No housing and rope is used. **The test only covers electrical and/or software efects!**

The GIE BLE Datalogger transfers each received data package via USB to the computer where the data are logged into a log file:



```
COM6 (115200 bps)
Connected to COM6 (115200 bps)  X  F  Baud rate: 115200
Ball: 12067958,1248,539,5,825,173,4,93
Ball: 12068751,1249,539,5,525,198,4,94
Ball: 12069569,1249,539,5,525,198,4,95
Ball: 12071180,1249,408,5,525,198,4,96
Ball: 12072794,1249,408,5,525,198,4,97
Ball: 12074406,1249,408,5,525,198,4,98
Ball: 12076018,1249,408,5,525,198,4,99
Ball: 12077632,1249,408,5,525,198,4,100
Ball: 12078258,1250,408,5,825,137,4,101
Ball: 12079243,1250,408,5,825,137,4,102
Ball: 12080854,1250,408,5,825,137,4,103
Ball: 12082466,1250,626,5,825,137,4,104
Ball: 12084078,1250,626,5,825,137,4,105
Ball: 12085737,1250,626,5,825,137,4,106
Ball: 12087347,1250,626,5,825,137,4,107
Ball: 12087800,1251,626,5,525,58,4,108
Ball: 12088960,1251,626,5,525,58,4,109
Ball: 12090573,1251,626,5,525,58,4,110
Ball: 12092183,1251,727,5,525,58,4,111
Ball: 12093793,1251,727,5,525,58,4,112
Ball: 12095406,1251,727,5,525,58,4,113
Ball: 12097015,1251,727,5,525,58,4,114
Ball: 12097297,1252,727,5,425,145,4,115
Ball: 12098628,1252,727,5,425,145,4,116
Ball: 12100238,1252,727,5,425,145,4,117
Ball: 12101846,1252,727,5,425,145,4,118
Ball: 12103458,1252,727,5,425,145,4,119
Ball: 12105068,1252,727,5,425,145,4,120
Ball: 12106680,1252,727,5,425,145,4,121
Ball: 12106789,1253,727,5,425,26,4,122
Ball: 12108289,1253,415,5,425,26,4,123
Ball: 12109901,1253,415,5,425,26,4,124
Ball: 12111512,1253,415,5,425,26,4,125
```

The transmission counter, which is included into the data package can be used to monitor data loss and/or communication breakdowns. The counter must increase from 0 to 255 permanently without gap and then overflow to 0 again:



In case of a communication loss the counter would jump to 0 at random count! Example of counter behavior can be provided by GIE but is not covered in this document.

The diagram above only shows part of the endurance test. The complete log file is stored at GIE and can be provided when necessary.

Conclusion:

Testdescription	FW	Result
BLE stability endurance test	105	OK

9 Anchor

Samples used for testing:

Bench Tests	
PCB Serial No.	100500 (C5)
FW Versions	54
Mechanics used	<ul style="list-style-type: none">- unmounted PCB, Loadcell mounted on plate- Powered by external powersource @3,0V
Integration in Ball (Functional Tests):	
PCB Serial No.	100502 (C5) 100503 (C5)
FW Versions	54
Mechanics used	<ul style="list-style-type: none">- Printed prototype Housing- Housing "Test Sample" <p>Old PCB Sample C1 was replaced with sample C5 Used button cell battery: muRata CR2032Lithium 3V</p>

9.1 *Integration Test*

9.1.1 Current consumption measurement

Current consumption is made on the test bench with external power supply @3,0V

Teststep	5.1.1.1
Description	Repower device after flashing/firmware update After repowering and calibration has finished LED must flash green 1/second Check Power consumption Power consumption shall be 10mA +/- TBD

Result/Deviation	OK
	 The image shows a digital scale's LCD screen displaying the value '-0.184' followed by 'gR'. Below the screen, there are several physical buttons labeled 'FUNCTION', 'M1', 'M2', 'M3', 'M4', 'M5', 'M6', 'M7', and 'M8'. The screen itself has a slight reflection.

9.1.2 Off-Mode timer behaviour and Off-Mode current

Teststep	5.1.2.1
Description	<p>Wait until device goes into Off-Mode (3min +/- 2sec.) Even with active connection. Check Power consumption</p> <ul style="list-style-type: none">- Not moving device, start timer, measure +/- 3minutes until device goes into Off-Mode- Move device again, connect BLE + BLE Uart, start timer, measure +/- 3 min. until device disconnects and goes into Off-Mode- Start device again, start timer, leave device unmoved until about 2 min. expired, move device, verify that device does not go into Off-Mode after 3 min! Device shall go into Off-Mode after 3 min. after last significant motion- Power consumption shall be 15uA +/- TBD
Result/Deviation	<p>OK (no connection) OK (connected) OK (reset 3 min. timer after device was moved)</p>
	 A photograph of a digital multimeter. The screen displays a negative value of -00.012 mA. Below the screen, there are two small green buttons labeled 'FUNCTION' and 'RESET'. To the right of the screen, there are two small blue buttons labeled 'CAL'.

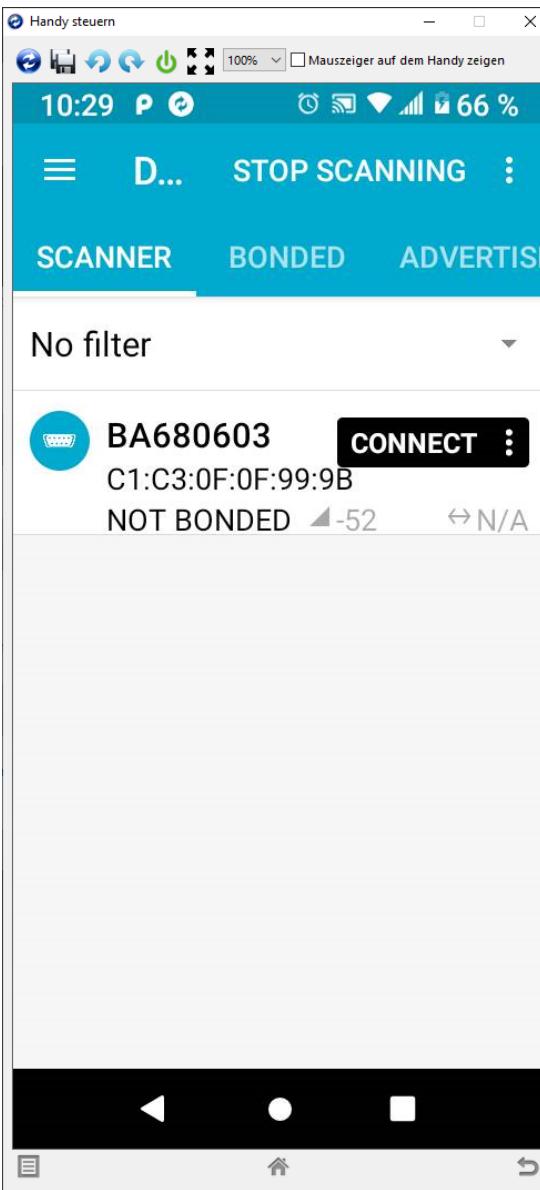
9.1.3 Offset Calibration and Startup/Shutdown

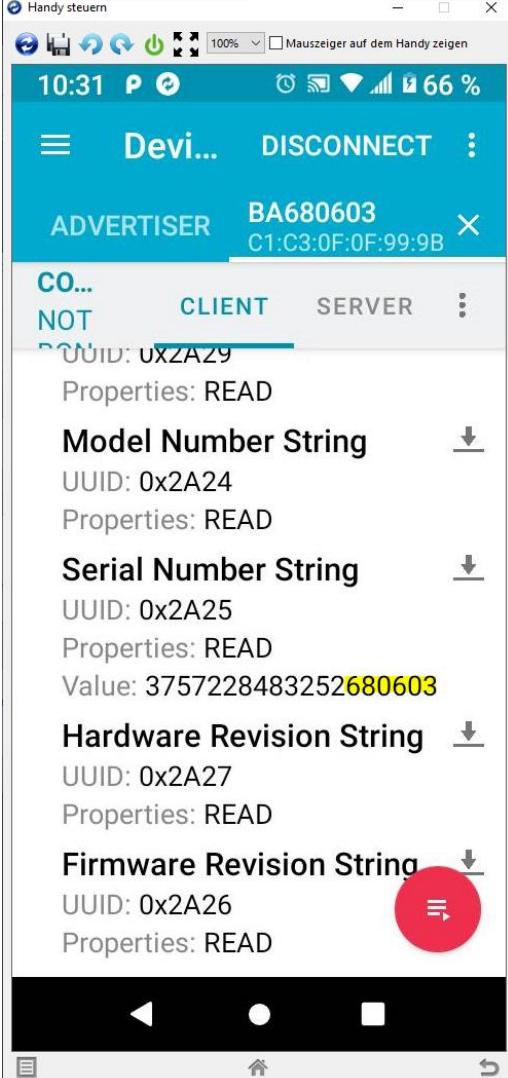
Teststep	5.1.3.1
Description	Repower device after flashing/firmware update After repowering LED must glow red (recalibration in progress)
Result/Deviation	OK

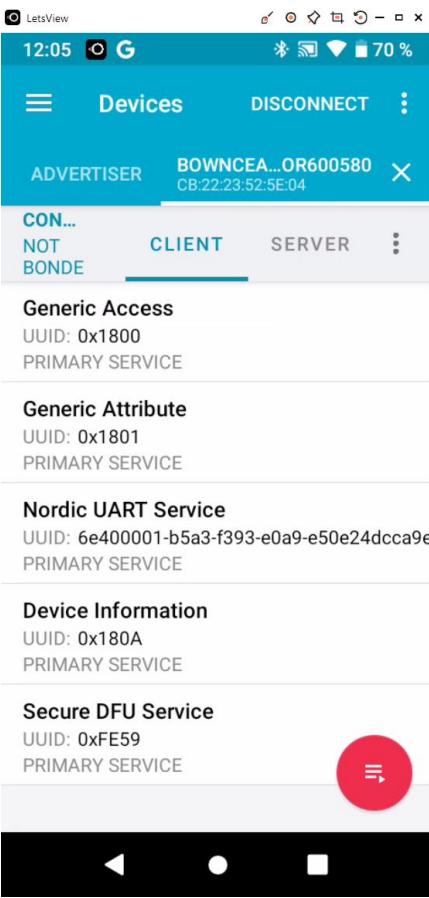
Teststep	5.1.3.2
Description	Wait until device goes into Off-Mode (3min +/- 2sec)
Result/Deviation	OK

Teststep	5.1.3.3
Description	Move device; Device must wake-up without recalibration; LED must Flash 2 times "fast" and then flash 1/Second green
Result/Deviation	OK

9.1.4 General BLE Connection behaviour

Teststep	5.1.4.1
Description	Scan the Device via Nordic nRF Connect App; Check the Device Name
Result/Deviation	OK Device Name must be BAxxxxxx
	

Teststep	5.1.4.2
Description	Connect to the Device Information Service and check the Serial number
Result/Deviation	OK
	

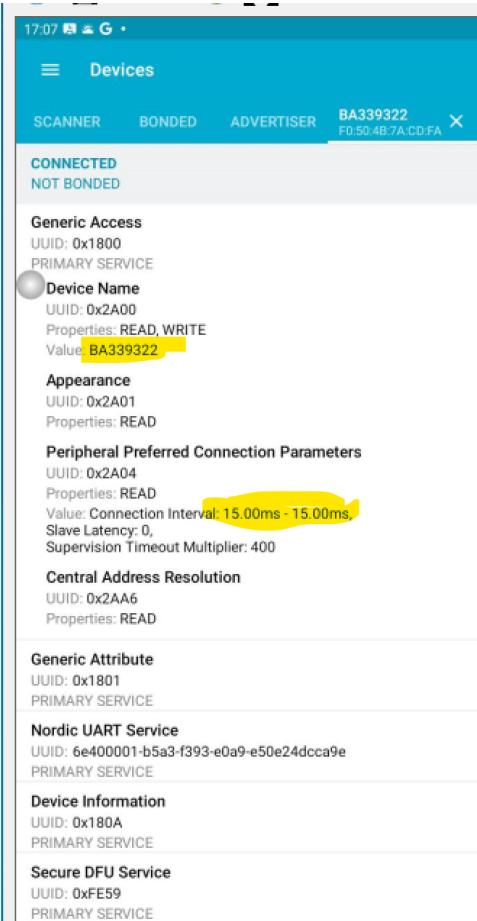
Teststep	5.1.4.3
Description	Connect to the Device via Nordic nRF Connect App; Check that the required services are available: Generic Access Generic Attribute Nordic UART Service Device Information Secure DFU Service
Result/Deviation	OK
	 The screenshot shows the 'Devices' screen of the nRF Connect app. A device named 'BOUNCEA...OR600580' (with address CB:22:23:52:5E:04) is connected as an 'ADVERTISER'. The 'CLIENT' tab is selected. The app lists several services: Generic Access (UUID: 0x1800, PRIMARY SERVICE), Generic Attribute (UUID: 0x1801, PRIMARY SERVICE), Nordic UART Service (UUID: 6e400001-b5a3-f393-e0a9-e50e24dcca9e, PRIMARY SERVICE), Device Information (UUID: 0x180A, PRIMARY SERVICE), and Secure DFU Service (UUID: 0xFE59, PRIMARY SERVICE). A red circular button with a right-pointing arrow is visible on the right side of the service list.

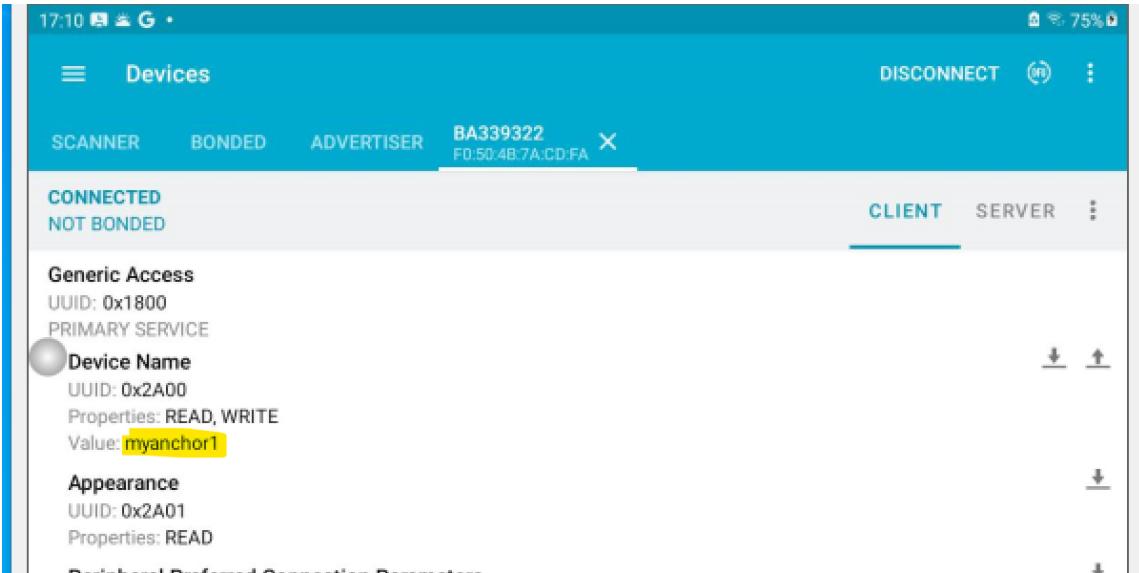
Teststep	5.1.4.4																		
Description	<p>Connect to the UART Service via nRF Connect App; Check that there is a notification received every <i>about</i> 1,5 seconds when there is no change in rope tension. Note: Sending the data frame during idle (no rope tension change) the time can vary since this is a low priority task!</p> <table border="1" data-bbox="436 572 1310 887"> <thead> <tr> <th>Byte</th> <th>Example</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0x23</td> <td>SOF (Start of Frame)</td> </tr> <tr> <td>1,2</td> <td>0x00-0x00</td> <td>Ropetension [g]</td> </tr> <tr> <td>3</td> <td>0x1D</td> <td>Battery level [V * 10]</td> </tr> <tr> <td>4</td> <td>0x25</td> <td>Transmission counter (0-255)</td> </tr> <tr> <td>5</td> <td>0x27</td> <td>EOF (End of Frame)</td> </tr> </tbody> </table> <p>Example: 0x23-0x00-0x00-0x20-0x0A-0x27 SOF / EOF Loadcell measurement in [g] Battery voltage in [V * 10] Transmission Counter [0 to 255 then over floating]</p> <p>10. Check the Transmission counter for a couple of seconds and check that the counter is ascending without gaps 11. Check the battery voltage (should be at 2,9 to 3,0 V with new Battery) 12. Load the loadcell with known load and check the output in the data frame 13. Check LED; must flash blue 14. Leave it running with established connection for at least 4 minutes. Device must go into Off-Mode anyway.</p>	Byte	Example	Description	0	0x23	SOF (Start of Frame)	1,2	0x00-0x00	Ropetension [g]	3	0x1D	Battery level [V * 10]	4	0x25	Transmission counter (0-255)	5	0x27	EOF (End of Frame)
Byte	Example	Description																	
0	0x23	SOF (Start of Frame)																	
1,2	0x00-0x00	Ropetension [g]																	
3	0x1D	Battery level [V * 10]																	
4	0x25	Transmission counter (0-255)																	
5	0x27	EOF (End of Frame)																	
Result/Deviation	OK																		

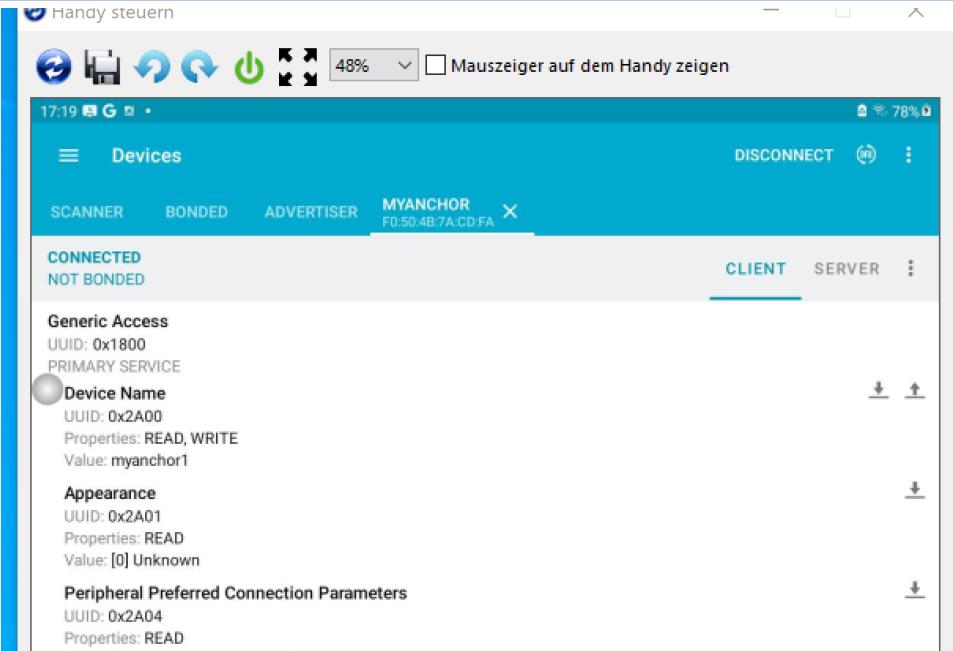
	<pre> Secure DFU Service (0xFE59) - Buttonless DFU [I W] (8ec90003-f315-4f60-9fb8-838830daea50) Client Characteristic Configuration (0x2902) 15:20:44.157 gatt.setCharacteristicNotification(00002a05-0000-1000-8000-00805f9b34fb, true) 15:20:44.159 gatt.setCharacteristicNotification(6e400003-b5a3-f393-e0a9-e50e24dcca9e, true) 15:20:44.185 Connection parameters updated (interval: 45.0ms, latency: 0, timeout: 5000ms) 15:20:48.732 Connection parameters updated (interval: 15.0ms, latency: 0, timeout: 4000ms) 15:20:49.893 Enabling notifications for 6e400003-b5a3-f393-e0a9-e50e24dcca9e 15:20:49.893 gatt.setCharacteristicNotification(6e400003-b5a3-f393-e0a9-e50e24dcca9e, true) 15:20:49.894 gatt.writeDescriptor(00002902-0000-1000-8000-00805f9b34fb, value=0x0100) 15:20:49.916 Data written to descr. 00002902-0000-1000-8000-00805f9b34fb, value: (0x) 01-00 15:20:49.916 "Notifications enabled" sent 15:20:49.925 Notifications enabled for 6e400003-b5a3-f393-e0a9-e50e24dcca9e 15:20:51.327 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x) 23-00-5A-1A-00-27 15:20:51.327 "#Z" received 15:20:52.527 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x) 23-00-3C-1A-01-27 15:20:52.527 "#<" received 15:20:52.722 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x) 23-00-5A-1A-02-27 15:20:52.722 "#Z" received 15:20:52.827 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x) 23-00-50-1A-03-27 15:20:52.827 "#P" received 15:20:54.328 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x) 23-00-5A-1A-04-27 15:20:54.328 "#Z" received 15:20:55.828 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x) 23-00-5A-1A-05-27 15:20:55.828 "#Z" received 15:20:57.328 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x) 23-00-5A-1A-06-27 15:20:57.328 "#Z" received 15:20:58.828 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x) 23-00-5A-1A-07-27 15:20:58.828 "#Z" received 15:20:59.698 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x) 23-00-64-1A-08-27 15:20:59.698 "#d" received 15:21:00.328 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x) 23-00-64-1A-09-27 15:21:00.328 "#d" received 15:21:00.898 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x) 23-00-32-1A-0A-27 15:21:00.898 "#2" received 15:21:01.092 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x) 23-00-64-1A-0B-27 15:21:01.092 "#d" received 15:21:01.828 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x) 23-00-6E-1A-0C-27 15:21:01.828 "#n" received </pre>

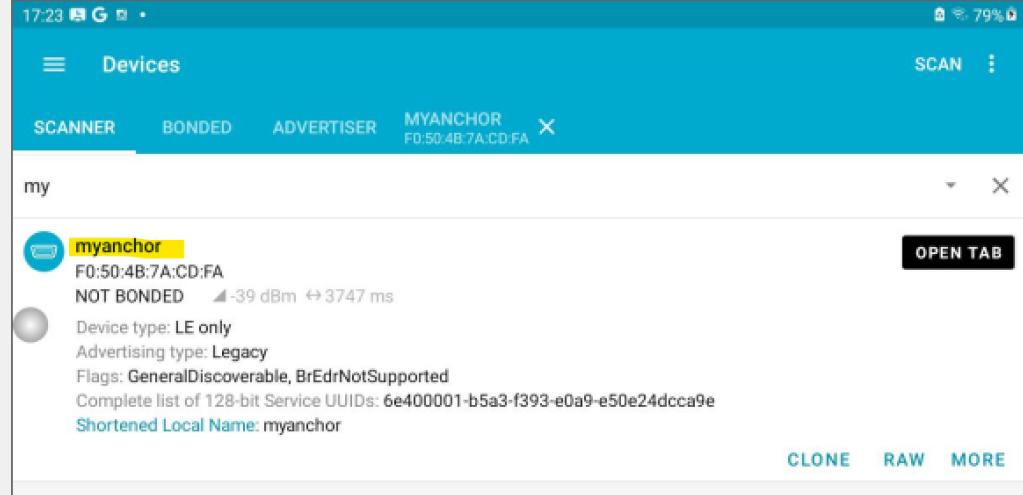
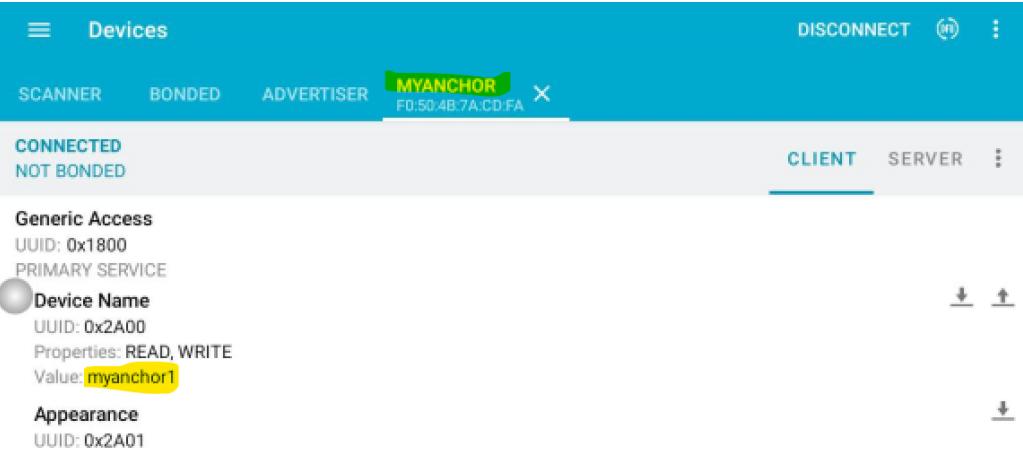
Teststep	5.1.4.5
Description	Connect to the Device Information Service (DIS) via nRF Connect App; Read the "Software Revision String" and check that it represents the current Version number.
Result/Deviation	OK

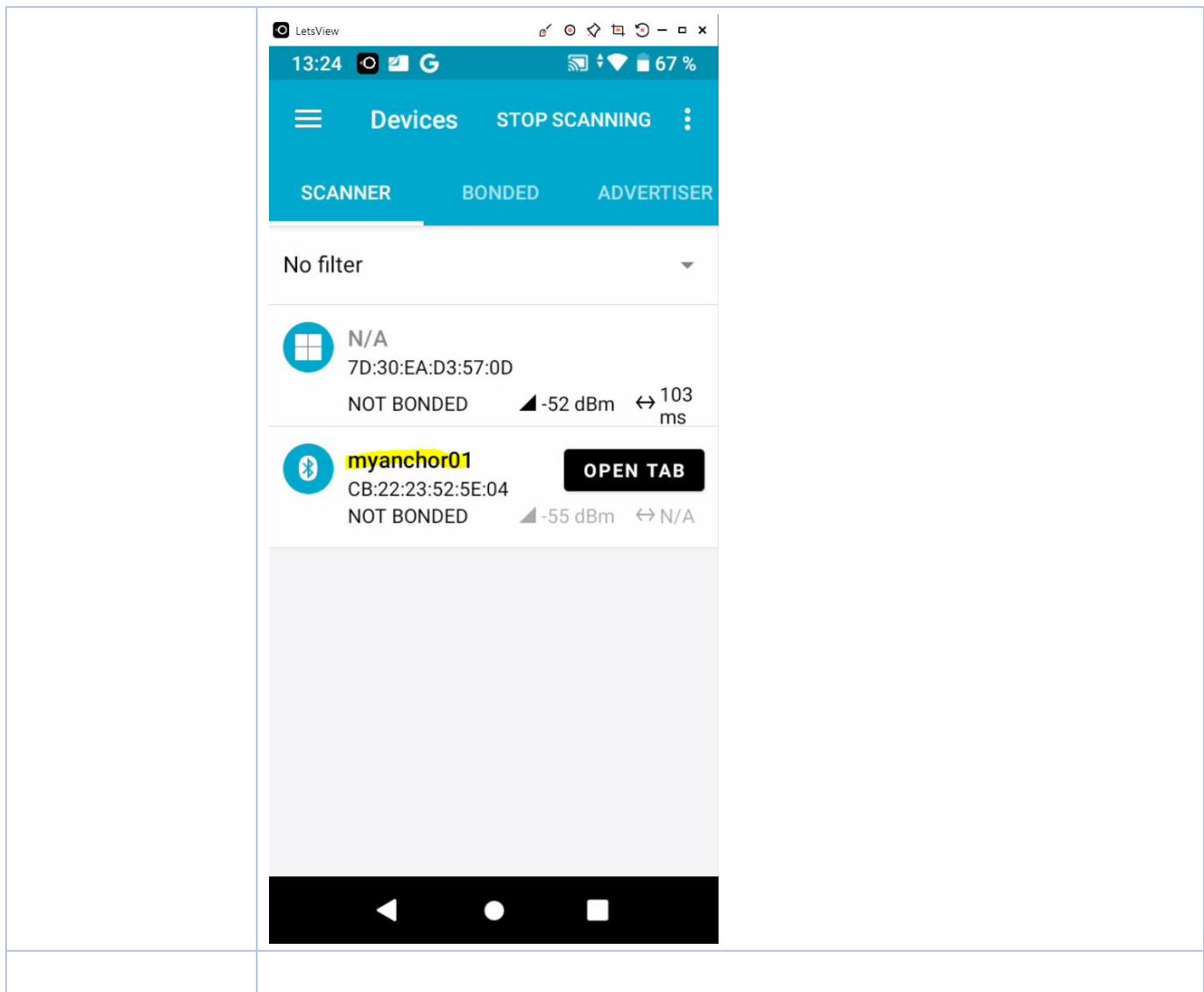
Devices	
SCANNER	BONDED
ADVERTISER	BA339322 F0:50:4B:7A:CD:FA X
CONNECTED	DISCONNECT
NOT BONDED	
Generic Access	
UUID: 0x1800	
PRIMARY SERVICE	
Generic Attribute	
UUID: 0x1801	
PRIMARY SERVICE	
Nordic UART Service	
UUID: 6e400001-b5a3-f393-e0a9-e50e24dcca9e	
PRIMARY SERVICE	
Device Information	
UUID: 0x180A	
PRIMARY SERVICE	
Manufacturer Name String	▼
UUID: 0x2A29	
Properties: READ	
Model Number String	▼
UUID: 0x2A24	
Properties: READ	
Serial Number String	▼
UUID: 0x2A25	
Properties: READ	
Hardware Revision String	▼
UUID: 0x2A27	
Properties: READ	
Firmware Revision String	▼
UUID: 0x2A26	
Properties: READ	
Software Revision String	▼
UUID: 0x2A28	
Properties: READ	
Value: 52	▼
System ID	▼

Teststep	5.1.4.6
Description	<p>Open the Tab “Generic Access Profile” GAP</p> <p>Read and check the device Name</p> <p>Read and check the “preferred connection”</p> <p>Must be 15ms/15ms/0/400</p>
Result/Deviation	Ok
	

Teststep	5.1.4.7
Description	Change the device name and re-read it right after changing it. Check that the device name was properly changed
Result/Deviation	OK
	

Teststep	5.1.4.8
Description	<p>Disconnect from the device by pressing “Disconnect” in the nRF App and close device tab.</p> <p>Go back to the Scanner in the nRF App, and re-scann for the device</p> <p>Check that the device is now advertising with the new name (if the name was longer than 8 characters the name will be shortened to 8!)</p> <p>Note: In the DIS the devicename shall be unshortend!</p>
Result/Deviation	OK
	

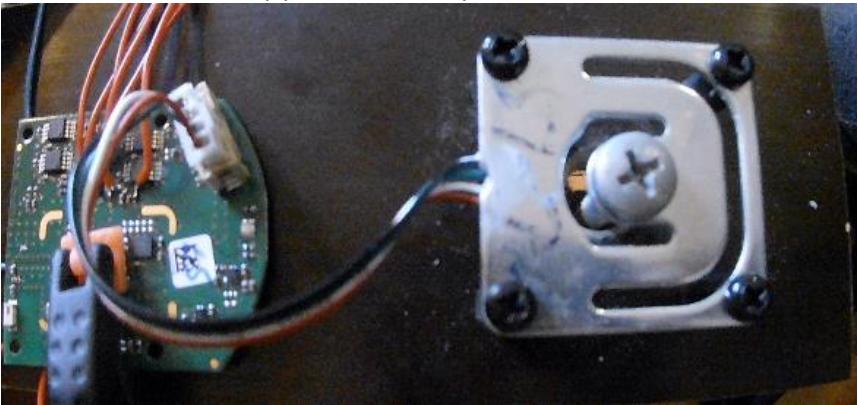
Teststep	5.1.4.9
Description	<p>Repower the device by removing the battery.</p> <p>Re-scan for the device with the nRF App.</p> <p>Check that the device is still advertising with its new name</p>
Result/Deviation	<p>OK</p>  

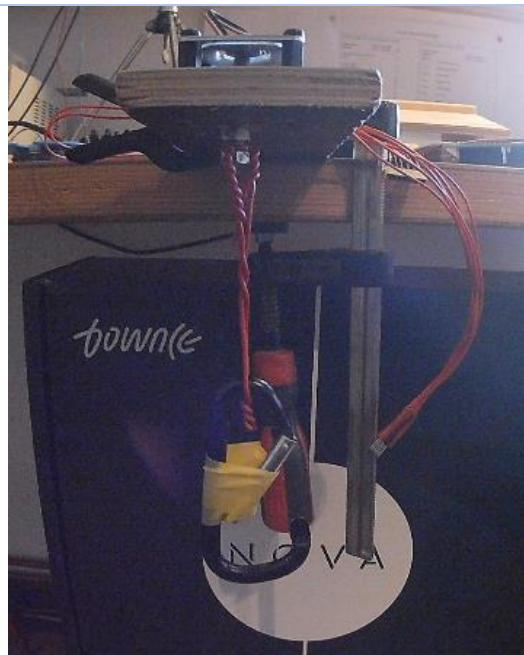


9.1.5 Factory reset behaviour

Teststep	5.1.5.1 (Factory Reset)
Description	Connect to the UART Service and send “3” (as character!) to device Disconnect the UART Service and repower the device The device must now advertise with the old name
Result/Deviation	OK - The Device name is cleared as well as the calibration data The Device needs to be re-powered to load the default values from ROM. Without re-powering the device name in advertising is empty and the calibration values are invalid!

9.1.6 Loadcell linearization

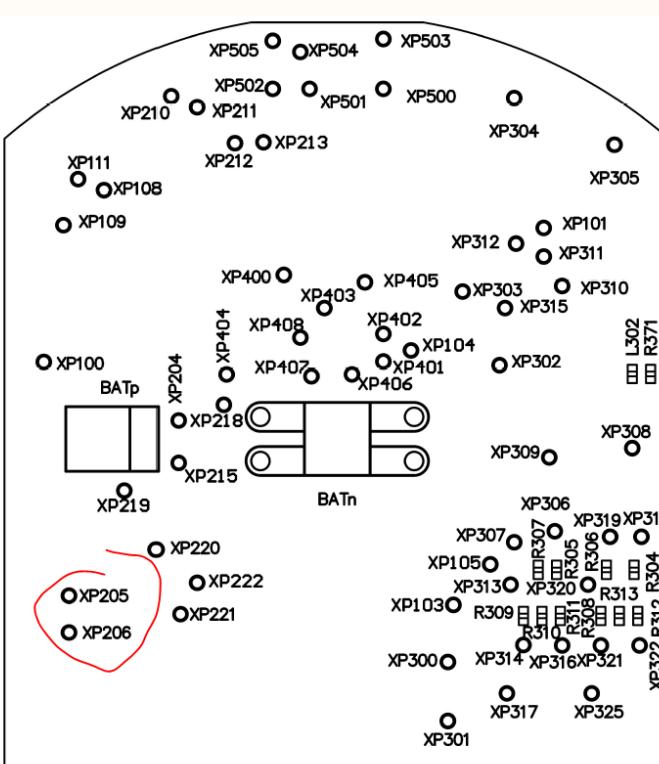
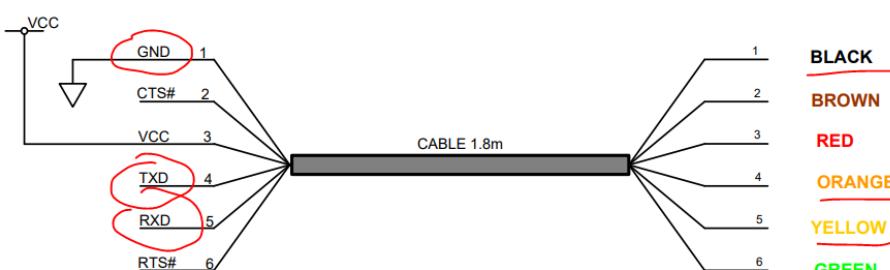
Teststep	5.1.6.1 (Factory Reset)
Description	Connect to the UART Service via GIE BLE Central Datalogger. Observe the Rope Tension. Load the loadcell with known weights. Loadcell must be mounted “overhead” on solid groundplate (No movement of the cell itself. Do not hold the cell free hands. This would result in inaccurate measurement) Calibrate the device by power off-on cycle 



Result/Deviation	Known weight Measurement																						
	477 g	479 g																					
	636 g	638 g																					
	797 g	807 g																					
	961 g	967 g																					
	1169 g	1166 g																					
	1403 g	1395 g																					
	<p>Known weight vs. anchor measurement</p> <table border="1"><caption>Data points estimated from the graph</caption><thead><tr><th>Sample</th><th>Known weight (g)</th><th>Measurement (g)</th></tr></thead><tbody><tr><td>1</td><td>450</td><td>450</td></tr><tr><td>2</td><td>650</td><td>650</td></tr><tr><td>3</td><td>850</td><td>850</td></tr><tr><td>4</td><td>1050</td><td>1050</td></tr><tr><td>5</td><td>1250</td><td>1250</td></tr><tr><td>6</td><td>1450</td><td>1450</td></tr></tbody></table> <p>Anchor: 479,28,71 Anchor: 479,28,72 Anchor: 479,28,73 Anchor: 479,28,74 Anchor: 479,28,75 Anchor: 479,28,76</p>		Sample	Known weight (g)	Measurement (g)	1	450	450	2	650	650	3	850	850	4	1050	1050	5	1250	1250	6	1450	1450
Sample	Known weight (g)	Measurement (g)																					
1	450	450																					
2	650	650																					
3	850	850																					
4	1050	1050																					
5	1250	1250																					
6	1450	1450																					

	Anchor: 638,28,126 Anchor: 638,28,127 Anchor: 638,28,128 Anchor: 638,28,129
	Anchor: 807,28,160 Anchor: 807,28,161 Anchor: 807,28,162 Anchor: 807,28,163 Anchor: 807,28,164 Anchor: 807,28,165
	Anchor: 967,28,184 Anchor: 967,28,185 Anchor: 967,28,186 Anchor: 967,28,187 Anchor: 967,28,188
	Anchor: 1166,28,212 Anchor: 1166,28,213 Anchor: 1166,28,214 Anchor: 1166,28,215 Anchor: 1166,28,216
	Anchor: 1395,28,46 Anchor: 1395,28,47 Anchor: 1395,28,48 Anchor: 1395,28,49
	OK

9.1.7 EOL-UART protocol test

Teststep	5.1.6.1 EOL Uart Protokoll Test
Description	<p>Test the EOL Uart Interface</p> <p>Connect the UART Interface via FTDI Cable (3V3)</p>  <p>6.1 TTL-232R-5V-WE, TTL-232R-3V3-WE Connections and Mechanical Details</p> <p>The following Figure 6.1 shows the cable signals and the wire colours for these signals on the TTL-232R-5V-WE and TTL-232R-3V3-WE cables.</p>  <p>Figure 6.1 TTL-232R-5V-WE and TTL-232R-3V3-WE Connections</p>

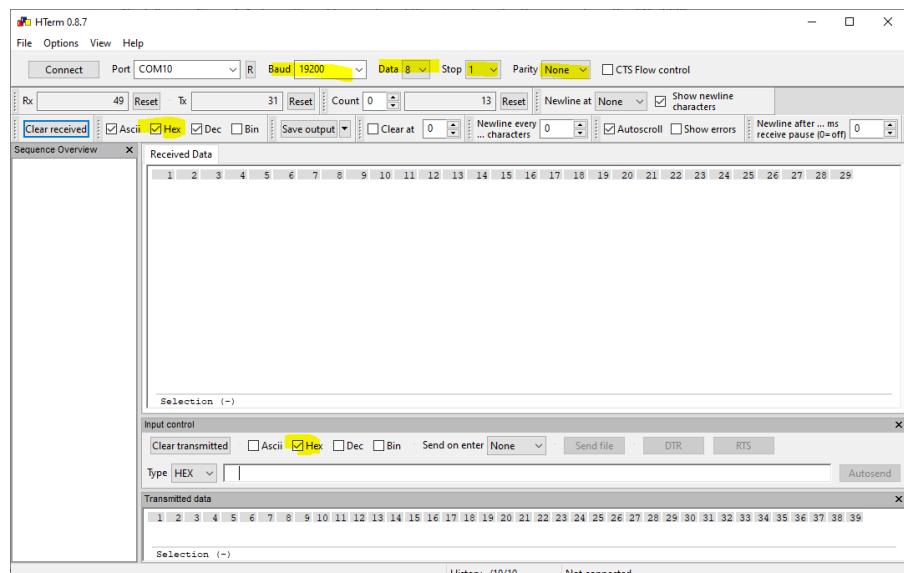
Wiring, Testpins C4 Sample (FW Version 104)

Signalname	Testpad on PCB	Function
BSP_EOL_UART_TX	XP205	Controller TxD
BSP_EOL_UART_RX	XP206	Controller RxD

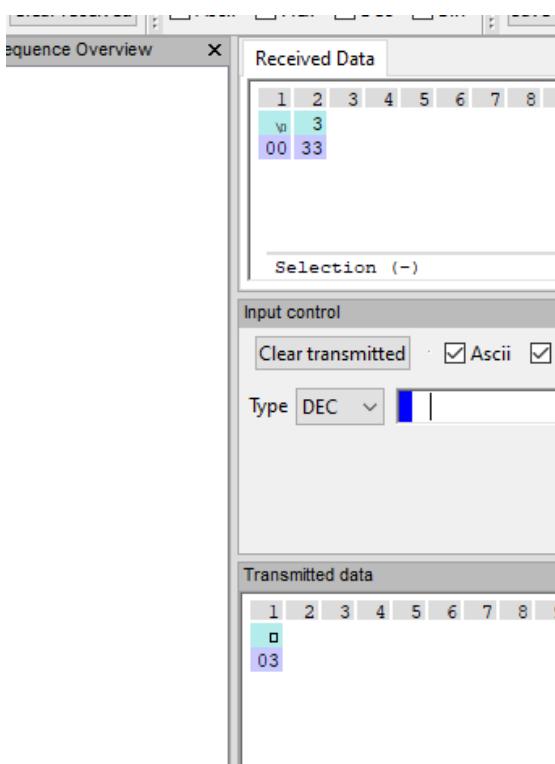
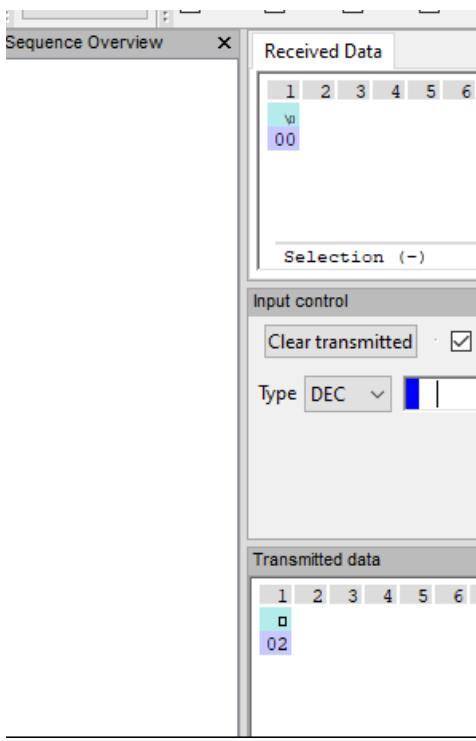
UART Commands:

Command	Description	Response
0x01	UART_CMD_GOTO_SLEEP	No Response. Device goes into Off-Mode immediately
0x02	UART_CMD_BMI270_SELFTEST	Device performs BMI270 Selftest for acceleration and gyro. Response 0x00 → Test passed Response 0x01 → Test failed
0x03	UART_CMD_GET_FW_VERSION	Device responds with FW Version (104)
0x04	UART_CMD_GET_UID	Device responds with 8 Digit Controller UID
0x09	UARTS_CMD_FINAL_DISABLE	Finally disable the EOL Test. No response

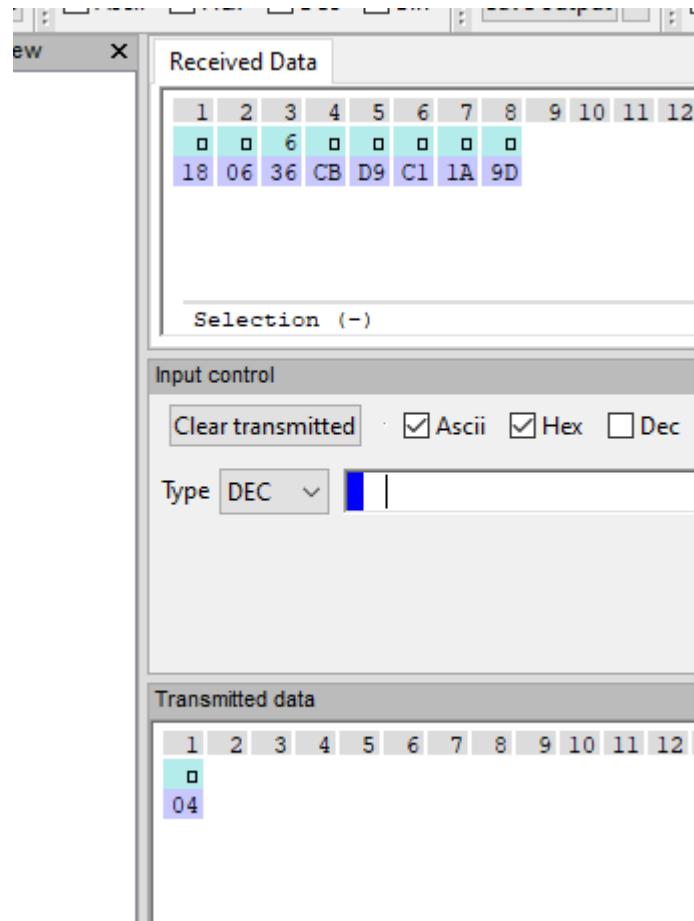
Terminal settings:



Use HTerm for testing, because HTerm is able to send/receive HEX values. With other (ASCII) Terminals it is necessary to calculate ASCII Values!

Result/Deviation	OK
	5.1.6.2: UART_CMD_GET_FW_VERSION 
	5.1.6.3 : UART_CMD_BMI270_SELFTEST 

5.1.6.4 : [UART_CMD_GET_UID](#)



5.1.6.5 : [UART_CMD_GOTO_SLEEP](#)

No response from device. Instead of response device goes into Off-Mode immediately after receiving the command. Check power consumption.

Result : 14 uA

(UART Interface has to be disconnected after device went into Off-Mode.
Do not shake the device when disconnecting the UART Interface)

With connected Interface the power consumption is not realistic because of pull up resistors inside the Interface!)

17.6 UARTS_CMD_FINAL_DISABLE

```
812
813     if (nv_data.spare4 != 12345)    nv_data.spare4|12345
814     {
815         gie_uart_init();
816         eol_uart_active = true;
817     }
818
```

9.2 Functional Test

9.2.1 Battery monitoring

Test: check if battery voltage monitoring in the ball correlates with “real” battery voltage

Test was done with FW Version 100

1. Battery was disassembled from battery tray. Voltage measured: **3,276V**
2. Battery assembled with ball. Ball starts advertising
3. Connect Ball with nFR App and request data frames via BLE UART profile
4. Ball transmits battery voltage 0x1Dh → **29** → **2,9V**
5. Deviation accepted because of voltage drop thru power consumption during data transmission

```
14:29:30.028 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x) 23-00-00-1D-00-27
14:29:30.028 "# " received
```

6. Ball went to Off-Mode

7. After wake up again

```
* buttonless button is held
Client Characteristic Configuration (0x2902)
14:34:30.189 gatt.setCharacteristicNotification(00002a05-0000-1000-8000-00805f9b34fb, true)
14:34:30.192 gatt.setCharacteristicNotification(6e400003-b5a3-f393-e0a9-e50e24dcca9e, true)
14:34:30.211 Connection parameters updated (interval: 45.0ms, latency: 0, timeout: 5000ms)
14:34:34.751 Connection parameters updated (interval: 15.0ms, latency: 0, timeout: 4000ms)
14:35:27.559 Enabling notifications for 6e400003-b5a3-f393-e0a9-e50e24dcca9e
14:35:27.559 gatt.setCharacteristicNotification(6e400003-b5a3-f393-e0a9-e50e24dcca9e, true)
14:35:27.560 gatt.writeDescriptor(00002902-0000-1000-8000-00805f9b34fb, value=0x0100)
14:35:27.613 Data written to descr. 00002902-0000-1000-8000-00805f9b34fb, value: (0x) 01-00
14:35:27.613 "Notifications enabled" sent
14:35:27.663 Notifications enabled for 6e400003-b5a3-f393-e0a9-e50e24dcca9e
14:35:27.986 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x) 23-00-0A-1B-00-27
14:35:27.986 "# "
" received
14:35:28.663 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x) 23-00-14-1B-01-27
14:35:28.663 "# "
" received
14:35:30.162 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x) 23-00-14-1B-02-27
14:35:30.162 "# "
" received
14:35:31.663 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x) 23-00-28-1B-03-27
14:35:31.663 "#(
" received
```

8.

8. Ball transmits battery voltage 0x1Bh → **27** → **2,7V**

Conclusion:

Testdescription	FW	Result
Batterie voltage monitoring	52	OK

9.2.2 General BLE connection/disconnection behaviour

9. Placing battery into anchor anchor lights up red until Calibration is ready.
10. Try to connect to Anchor, connection was established after 3. Attempt. Result accepted, first connection can take some more time since devices negotiate connection parameters for the first time!

```

SCANNER      BONDED      ADVERTISER      BA113043      X
DISCONNECTED      NOT BONDED      CLIENT      SERV

14:29:13.275 Connecting to DD:71:D0:53:31:53...
14:29:13.275 gatt = device.connectGatt(autoConnect = false, TRANSPORT_LE, preferred PHY = LE 1M)
14:29:13.562 [Broadcast] Action received: android.bluetooth.device.action.ACL_CONNECTED
14:29:13.583 [Callback] Connection state changed with status: 0 and new state: CONNECTED (2)
14:29:13.583 Connected to DD:71:D0:53:31:53
14:29:13.610 Discovering services...
14:29:13.610 gatt.discoverServices()
14:29:13.947 Connection parameters updated (interval: 7.5ms, latency: 0, timeout: 5000ms)
14:29:14.235 [Callback] Services discovered with status: 0
14:29:14.235 Services discovered
14:29:14.271 Generic Access (0x1800)
    - Device Name [R W] (0x2A00)
    - Appearance [R] (0x2A01)
    - Peripheral Preferred Connection Parameters [R] (0x2A04)
    - Central Address Resolution [R] (0x2AA6)
    Generic Attribute (0x1801)
    - Service Changed [I] (0x2A05)
        Client Characteristic Configuration (0x2902)
    Nordic UART Service (6e400001-b5a3-f393-e0a9-e50e24dcca9e)
    - RX Characteristic [W WNR] (6e400002-b5a3-f393-e0a9-e50e24dcca9e)
    - TX Characteristic [N] (6e400003-b5a3-f393-e0a9-e50e24dcca9e)
        Client Characteristic Configuration (0x2902)
    Device Information (0x180A)
    - Manufacturer Name String [R] (0x2A29)
    - Model Number String [R] (0x2A24)
    - Serial Number String [R] (0x2A25)
    - Hardware Revision String [R] (0x2A27)
    - Firmware Revision String [R] (0x2A26)
    - Software Revision String [R] (0x2A28)
    - System ID [R] (0x2A23)
    - IEEE 11073-20601 Regulatory Certification Data List [R] (0x2A2A)
    - PnP ID [R] (0x2A50)
    Secure DFU Service (0xFE59)
    - Buttonless DFU [I W] (8ec90003-f315-4f60-9fb8-838830daea50)
        Client Characteristic Configuration (0x2902)
14:29:14.272 gatt.setCharacteristicNotification(00002a05-0000-1000-8000-00805f9b34fb, true)
14:29:14.274 gatt.setCharacteristicNotification(6e400003-b5a3-f393-e0a9-e50e24dcca9e, true)
14:29:14.306 Connection parameters updated (interval: 45.0ms, latency: 0, timeout: 5000ms)
14:29:18.850 Connection parameters updated (interval: 15.0ms, latency: 0, timeout: 4000ms)
14:29:29.517 Enabling notifications for 6e400003-b5a3-f393-e0a9-e50e24dcca9e
14:29:29.517 gatt.setCharacteristicNotification(6e400003-b5a3-f393-e0a9-e50e24dcca9e, true)
14:29:29.519 gatt.writeDescriptor(00002902-0000-1000-8000-00805f9b34fb, value=0x0100)
14:29:29.547 Data written to descr. 00002902-0000-1000-8000-00805f9b34fb, value: (0x) 01-00
14:29:29.547 "Notifications enabled" sent
14:29:29.556 Notifications enabled for 6e400003-b5a3-f393-e0a9-e50e24dcca9e
14:29:30.028 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x) 23-00-00-1D-00-27
14:29:30.028 "# " received
14:29:31.527 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x) 23-00-00-1D-01-27
14:29:31.527 "# " received

```

11. Wait until Anchor goes into Off-mode

Baseline Test Bounce Ball (C4 Sample), Anchor (C5 Sample)

```

14:29:49.527 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x) 23-00-00-1C-0D-27
14:29:49.527 "# " received
14:29:51.028 Notification received from 6e400003-b5a3-f393-e0a9-e50e24dcca9e, value: (0x) 23-00-00-1C-0E-27
14:29:51.028 "# " received
14:29:51.433 Disabling notifications for 6e400003-b5a3-f393-e0a9-e50e24dcca9e
14:29:51.433 gatt.setCharacteristicNotification(6e400003-b5a3-f393-e0a9-e50e24dcca9e, false)
14:29:51.434 gatt.writeDescriptor(00002902-0000-1000-8000-00805f9b34fb, value=0x0000)
14:29:51.462 Data written to descr. 00002902-0000-1000-8000-00805f9b34fb, value: (0x) 00-00
14:29:51.462 "Notifications and indications disabled" sent
14:29:51.463 Notifications and indications disabled for 6e400003-b5a3-f393-e0a9-e50e24dcca9e
14:32:20.512 [Callback] Connection state changed with status: 8 and new state: DISCONNECTED (0)
14:32:20.512 Error 8 (0x8): GATT CONN TIMEOUT
14:32:20.512 Disconnected
14:32:20.640 [Broadcast] Action received: android.bluetooth.device.action.ACL_DISCONNECTED

```

12. Time until Anchor went into Off-mode about 3 Min.

13. Shaking Anchor wakes up green LED is flashing. Connecting via app connection successfully

```

14:32:20.512 Error 8 (0x8): GATT CONN TIMEOUT
14:32:20.512 Disconnected
14:32:20.640 [Broadcast] Action received: android.bluetooth.device.action.ACL_DISCONNECTED
14:34:25.164 gatt.close()
14:34:25.172 wait(200)
14:34:25.372 Connecting to DD:71:D0:53:31:53...
14:34:25.372 gat = device.connectGatt(autoConnect = false, TRANSPORT_LE, preferred PHY = LE 1M)
14:34:29.459 [Broadcast] Action received: android.bluetooth.device.action.ACL_CONNECTED
14:34:29.493 [Callback] Connection state changed with status: 0 and new state: CONNECTED (2)
14:34:29.493 Connected to DD:71:D0:53:31:53
14:34:29.529 Discovering services...
14:34:29.529 gatt.discoverServices()
14:34:30.088 Connection parameters updated (interval: 7.5ms, latency: 0, timeout: 5000ms)
14:34:30.151 [Callback] Services discovered with status: 0
14:34:30.151 Services discovered
14:34:30.189 Generic Access (0x1800)
  - Device Name [R W] (0x2A00)
  - Appearance [R] (0x2A01)
  - Peripheral Preferred Connection Parameters [R] (0x2A04)
  - Central Address Resolution [R] (0x2AA6)
  - Generic Attribute (0x1801)
  - Service Changed [I] (0x2A05)
    Client Characteristic Configuration (0x2902)
  - Nordic UART Service (6e400001-b5a3-f393-e0a9-e50e24dcca9e)
  - RX Characteristic [W WNR] (6e400002-b5a3-f393-e0a9-e50e24dcca9e)
  - TX Characteristic [N] (6e400003-b5a3-f393-e0a9-e50e24dcca9e)
    Client Characteristic Configuration (0x2902)
  - Device Information (0x180A)
  - Manufacturer Name String [R] (0x2A29)
  - Model Number String [R] (0x2A24)
  - Serial Number String [R] (0x2A25)
  - Hardware Revision String [R] (0x2A27)
  - Firmware Revision String [R] (0x2A26)
  - Software Revision String [R] (0x2A28)
  - System ID [R] (0x2A23)
  - IEEE 11073-20601 Regulatory Certification Data List [R] (0x2A2A)
  - PnP ID [R] (0x2A50)
  - Secure DFU Service (0xFE59)
  - Buttonless DFU [I W] (8ec90003-f315-4f60-9fb8-838830daea50)
    Client Characteristic Configuration (0x2902)
14:34:30.189 gatt.setCharacteristicNotification(00002a05-0000-1000-8000-00805f9b34fb, true)
14:34:30.191 gatt.setCharacteristicNotification(6e400003-b5a3-f393-e0a9-e50e24dcca9e, true)
14:34:30.211 Connection parameters updated (interval: 45.0ms, latency: 0, timeout: 5000ms)
14:34:34.751 Connection parameters updated (interval: 15.0ms, latency: 0, timeout: 4000ms)

```

Conclusion:

Testdescription	FW	Result
BLE connect/disconnect behaviour	52	OK

10 Appendix

10.1 Appendix A

Logfiles battery monitoring



Log 2022-09-14 Log 2022-09-14
13_35_18_battery_be14_15_26_Battery_be

10.2 Appendix B

BLE Central Datalogger

Com Parameter:

115200/8/n/1 No Flowcontrol

Preparation of nRF52 DevKit:

- Brücke/Jumper "nRF current measurement" stecken

-

RxD	GPIO15 an Devkit --> auf TxD an FTDI Kabel (orange)
TxD	GPIO14 an Devkit --> auf RxD an FTDI Kabel (yellow)

- FTDI Kabel: [TTL-232R \(farnell.com\)](https://www.farnell.com)

6.1 TTL-232R-5V-WE, TTL-232R-3V3-WE Connections and Mechanical Details

The following Figure 6.1 shows the cable signals and the wire colours for these signals on the TTL-232R-5V-WE and TTL-232R-3V3-WE cables.

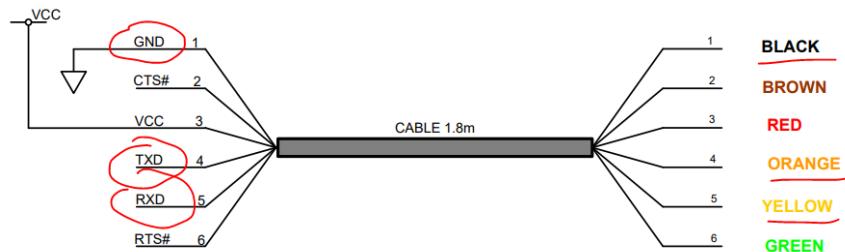
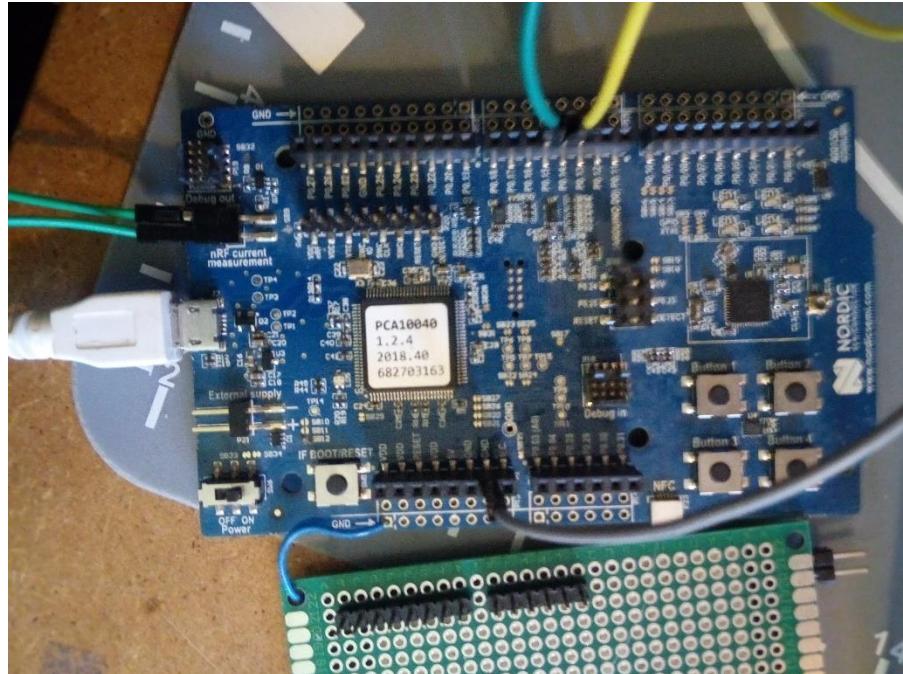


Figure 6.1 TTL-232R-5V-WE and TTL-232R-3V3-WE Connections

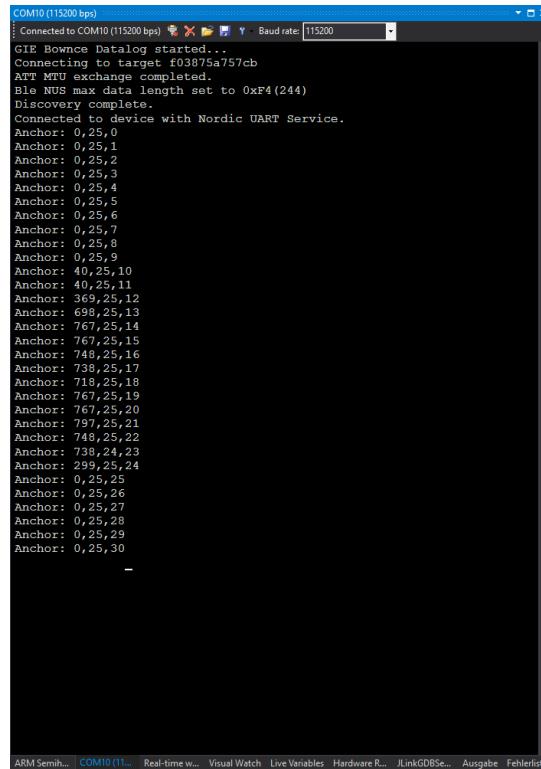
Quellcode und HEX-File hier:

<\\GEG-ADDS->

1\GIE Work\GIE Design Archiv\Software 50x\505025_001_FW_Bounce_C1-Sample-DTM-Radiotest

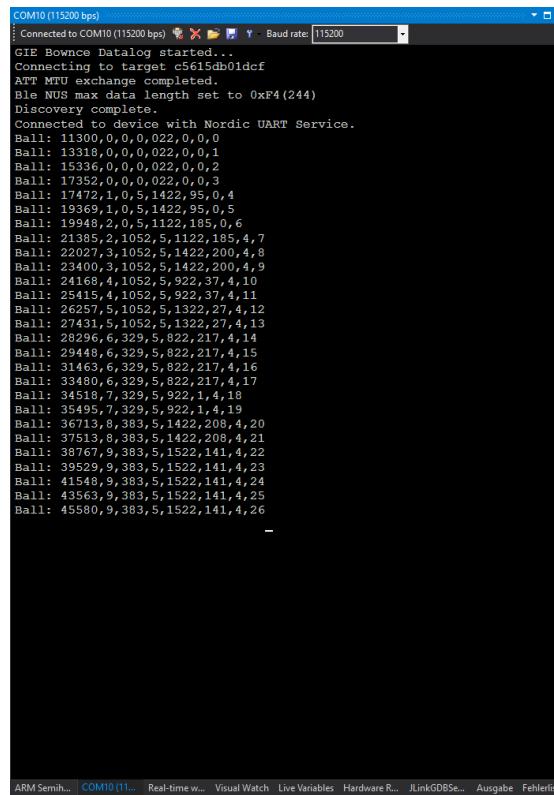


Anchor:



```
COM10 (115200 bps)
Connected to COM10 (115200 bps) Baud rate: 115200
GIE Bounce Datalog started...
Connecting to target f03875a757cb
ATT MTU exchange completed.
Ble NUS max data length set to 0xF4 (244)
Discovery complete.
Connected to device with Nordic UART Service.
Anchor: 0,25,0
Anchor: 0,25,1
Anchor: 0,25,2
Anchor: 0,25,3
Anchor: 0,25,4
Anchor: 0,25,5
Anchor: 0,25,6
Anchor: 0,25,7
Anchor: 0,25,8
Anchor: 0,25,9
Anchor: 40,25,10
Anchor: 40,25,11
Anchor: 369,25,12
Anchor: 698,25,13
Anchor: 767,25,14
Anchor: 767,25,15
Anchor: 748,25,16
Anchor: 738,25,17
Anchor: 718,25,18
Anchor: 767,25,19
Anchor: 767,25,20
Anchor: 797,25,21
Anchor: 748,25,22
Anchor: 738,24,23
Anchor: 299,25,24
Anchor: 0,25,25
Anchor: 0,25,26
Anchor: 0,25,27
Anchor: 0,25,28
Anchor: 0,25,29
Anchor: 0,25,30
```

Ball:



```
COM10 (115200 bps)
Connected to COM10 (115200 bps) Baud rate: 115200
GIE Bounce Datalog started...
Connecting to target c5615db01dcf
ATT MTU exchange completed.
Ble NUS max data length set to 0xF4 (244)
Discovery complete.
Connected to device with Nordic UART Service.
Ball: 11300,0,0,0,022,0,0
Ball: 13318,0,0,0,022,0,0,1
Ball: 15336,0,0,0,022,0,0,2
Ball: 17352,0,0,0,022,0,0,3
Ball: 17472,1,0,5,1422,95,0,4
Ball: 19369,1,0,5,1422,95,0,5
Ball: 19948,2,0,5,1122,185,0,6
Ball: 21385,2,1052,5,1122,185,4,7
Ball: 22027,3,1052,5,1422,200,4,8
Ball: 23400,3,1052,5,1422,200,4,9
Ball: 24168,4,1052,5,922,37,4,10
Ball: 25415,4,1052,5,922,37,4,11
Ball: 26257,5,1052,5,1322,27,4,12
Ball: 27431,5,1052,5,1322,27,4,13
Ball: 28296,6,329,5,822,217,4,14
Ball: 29448,6,329,5,822,217,4,15
Ball: 31463,6,329,5,822,217,4,16
Ball: 33480,6,329,5,822,217,4,17
Ball: 34518,7,329,5,922,1,4,18
Ball: 35495,7,329,5,922,1,4,19
Ball: 36713,8,383,5,1422,208,4,20
Ball: 37513,8,383,5,1422,208,4,21
Ball: 38767,9,383,5,1522,141,4,22
Ball: 39529,9,383,5,1522,141,4,23
Ball: 41548,9,383,5,1522,141,4,24
Ball: 43563,9,383,5,1522,141,4,25
Ball: 45580,9,383,5,1522,141,4,26
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**Baseline Test Bounce Ball (C4 Sample),
Anchor (C5 Sample)**

