ams

Application Note

LFT POC

Description of Device Firmware Version 2.1.1

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Content Guide

1 Introduction

This application note describes the functionality of the device firmware and the Bluetooth LE services and characteristics it uses. LFT POC stands for "Lateral Flow Test Point of Care".

Please consider the following important notes about device behavior:

Information

- The sample is detected by a physical push button inside the case. This button also serves as a power on/off switch. Please refer to sections 1.1 for turning the device on and off and 1.2 for more details about sample detection.

- The device shuts itself off after 15 minutes of inactivity, if BLE is not connected or USB is unplugged. A BLE connection or plugging in the USB resets and stops the timer. BLE disconnection or unplugging the USB restarts the timer.

- If battery voltage crosses the 3290 mV minimum threshold while BLE is connected, a low battery voltage alert notification is sent over the Operations Control characteristic.

1.1 Turning the Device On and Off

If running on battery, turning on the device also starts BLE advertisement. If USB power is connected, BLE advertisement must be started by inserting a sample.

Turning on:

- If no USB is plugged in, the device can be turned on by inserting a sample (for at least 1 s), which will also start BLE advertisement immediately.
- If USB is plugged in, the device turns on automatically, and the battery is charged, if necessary. In order to start BLE advertisement, a sample must be inserted (for at least 1 s).

Turning off:

- If no USB is plugged in, reinserting a sample 3 times within 5 s causes the device to shut itself off, even if connected over BLE. Pull the sample out by about 1 cm and then push it all the way back – repeat it 3 times within 5 s.
- If USB is plugged in and BLE is advertising or connected, the device cannot be turned off by reinserting the sample 3 times, as described in the previous point. Remove USB power first and then proceed with reinserting the sample.
- If USB is plugged in and BLE is not advertising or not connected, removing USB power will turn off the device.

1.2   Sample Detection

Sample detection relies on signals from the internal push button. It will only work as expected, **if the sample is shortly pulled out after the device/BLE has been turned on by inserting a sample.**

2 Specification

The LFT POC device is equipped with an nRF52832 chip, which supports Bluetooth Low Energy. Communication is done via the different characteristics of the custom LFT POC service and specific Nordic/Bluetooth SIG services. It is assumed, that the BLE device guarantees data delivery/reception as packets to/from the mobile application. Data flows in both directions. LFT POC communicates via I^2C with three AS7341L spectral sensors. Upon power on, the following sensor registers are initialized with default values:

Figure 1:
Default Configuration Register Values

Configuration Name	Default Value
ASTEP	65534
ATIME	0
AGAIN	9
LED_DRIVE	4

3 BLE GATT Server

LFT POC runs a GATT server to communicate on BLE through the following services and characteristics.

Figure 2:
BLE GATT Services

Service	UUID	Description
LFT POC	*31f58611-cac6-488c-8b8b-e1b4c5d00a8c*	Primary Service
Battery	*0x180F*	Primary Service
Device Information	*0x180A*	Primary Service
Nordic Secure DFU	*0xFE59*	Primary Service

Figure 3:
BLE GATT Characteristics

Attribute	UUID	Capabilities
Button	*31f58612-cac6-488c-8b8b-e1b4c5d00a8c*	Notify, Read
Operations Control	*31f58613-cac6-488c-8b8b-e1b4c5d00a8c*	Notify, Read, Write
Spectral	*31f58615-cac6-488c-8b8b-e1b4c5d00a8c*	Notify, Read
Configuration	*31f58616-cac6-488c-8b8b-e1b4c5d00a8c*	Notify, Read, Write
Nordic Buttonless DFU	*0x1531*	Notify, Read
Battery Level	*0x2A19*	Indicate, Write
Manufacturer Name	*0x2A29*	Read
Model Number	*0x2A24*	Read
Serial Number	*0x2A25*	Read
Hardware Revision	*0x2A27*	Read
Firmware Revision	*0x2A26*	Read

These UUID's are initialized in LFT POC on BLE start up. On mobile application, the UUID's can be auto identified by the GATT server services identifier request.

On mobile application, BLE scan can search with the LFT POC UUID, so that the BLE service scans for the LFT POC Bluetooth devices only, other Bluetooth devices are filtered out.

4 LFT POC Sensor Data Specification

The device incorporates three AS7341L spectral sensors. Each sensor measures F1-F8, Clear and NIR.

Figure 4:
Sensor Data Specification

Sensor	Type	Unit	Range	Frequency
AS7341L	Spectral sensor	Counts	0 to 65535	On trigger by client application

5 BLE Characteristics

5.1 Spectral Characteristic

If measurement data is ready, this characteristic sends a notification to the mobile application (first 20 bytes), which in turn reads all 72 bytes. The data array consists of 36 unsigned 16-bit integers. Clear and NIR are measured twice.

5.1.1 Measurement Data Array

Figure 5:
Sensor 1 Data Array

Byte Index	Data	Byte Index	Data
0	F1 Lower Byte	12	F5 Lower Byte
1	F1 Higher Byte	13	F5 Higher Byte
2	F2 Lower Byte	14	F6 Lower Byte
3	F2 Higher Byte	15	F6 Higher Byte
4	F3 Lower Byte	16	F7 Lower Byte
5	F3 Higher Byte	17	F7 Higher Byte
6	F4 Lower Byte	18	F8 Lower Byte
7	F4 Higher Byte	19	F8 Higher Byte
8	Clear Lower Byte	20	Clear Lower Byte
9	Clear Higher Byte	21	Clear Higher Byte
10	NIR Lower Byte	22	NIR Lower Byte
11	NIR Higher Byte	23	NIR Higher Byte

Figure 6:
Sensor 2 Data Array

Byte Index	Data	Byte Index	Data
24	F1 Lower Byte	36	F5 Lower Byte
25	F1 Higher Byte	37	F5 Higher Byte
26	F2 Lower Byte	38	F6 Lower Byte
27	F2 Higher Byte	39	F6 Higher Byte
28	F3 Lower Byte	40	F7 Lower Byte

Byte Index	Data	Byte Index	Data
29	F3 Higher Byte	41	F7 Higher Byte
30	F4 Lower Byte	42	F8 Lower Byte
31	F4 Higher Byte	43	F8 Higher Byte
32	Clear Lower Byte	44	Clear Lower Byte
33	Clear Higher Byte	45	Clear Higher Byte
34	NIR Lower Byte	46	NIR Lower Byte
35	NIR Higher Byte	47	NIR Higher Byte

Figure 7:
Sensor 3 Data Array

Byte Index	Data	Byte Index	Data
48	F1 Lower Byte	60	F5 Lower Byte
49	F1 Higher Byte	61	F5 Higher Byte
50	F2 Lower Byte	62	F6 Lower Byte
51	F2 Higher Byte	63	F6 Higher Byte
52	F3 Lower Byte	64	F7 Lower Byte
53	F3 Higher Byte	65	F7 Higher Byte
54	F4 Lower Byte	66	F8 Lower Byte
55	F4 Higher Byte	67	F8 Higher Byte
56	Clear Lower Byte	68	Clear Lower Byte
57	Clear Higher Byte	69	Clear Higher Byte
58	NIR Lower Byte	70	NIR Lower Byte
59	NIR Higher Byte	71	NIR Higher Byte

5.2 Configuration Characteristic

This characteristic receives commands from the mobile application to read/write sensor configurations and it is also used to send configuration read/write reports to the mobile application. The characteristic is 10 bytes long.

Figure 8:
Command Codes

Command	Code
Read	0x00
Write	0x01

Figure 9:
Report Codes

Report	Code
Read	0x02
Write	0x03

Figure 10:
Configuration Codes

Configuration	Code
ASTEP	0x01
ATIME	0x02
LED_DRIVE	0x03
AGAIN	0x04

Figure 11:
I^{2}C Read/Write Error Codes

Status	Code
All Sensors Success	0x00
Sensor 1 Fail	0x01
Sensor 2 Fail	0x02
Sensor 3 Fail	0x03
Sensor 1 + Sensor 2 Fail	0x04
Sensor 1 + Sensor 3 Fail	0x05
Sensor 2 + Sensor 3 Fail	0x06
Sensor 1 + Sensor 2 + Sensor 3 Fail	0x07

5.2.1 Configuration Read Command

The mobile application writes the command to the configuration characteristic and the device responds with a Configuration Read Report notification.

Length: 2 bytes

Figure 12:
Configuration Read Command

Byte 0	Byte 1
Read command code	Configuration code

5.2.2 Configuration Write Command

The mobile application writes the command to the configuration characteristic and the device responds with a Configuration Write Report notification.

Length: 4 bytes

Figure 13:
Configuration Write Command

Byte 0	Byte 1	Byte 2	Byte 3
Write command code	Configuration code	Data LSB	Data MSB

5.2.3 Configuration Read Report

This report is sent to the mobile application as a notification, after receiving the read command.

Length: 10 bytes

Figure 14:
Configuration Read Report

Byte Index	Value
0	Read report code
1	Configuration code
2	I^2C read/write error code
3	0
4	Sensor 1 data LSB

Byte Index	Value
5	Sensor 1 data MSB
6	Sensor 2 data LSB
7	Sensor 2 data MSB
8	Sensor 3 data LSB
9	Sensor 3 data MSB

5.2.4 Configuration Write Report

This report is sent to the mobile application as notification, after receiving the write command.

Length: 10 bytes

Figure 15:
Configuration Write Report

Byte 0	Byte 1	Byte 2	Byte 3-9
Write report code	Configuration code	I^2C read/write error code	0

5.3 Operations Control Characteristic

This characteristic is used to start the measurement from the mobile application. When the device receives the command and the measurement is finished for all 3 sensors, the spectral characteristic sends a notification.

If the battery voltage crosses the minimum threshold (3290 mV), this characteristic is used to send a low battery alert notification.

Length: 1 byte

Figure 16:
Command and Status Codes

Command / Status Report	Code
Start measurement command	0x01
Low battery alert status report	0x03

5.4 Button Characteristic

The button characteristic stores the actual state of the push button. If BLE is connected, a notification is sent upon button state change (sample status). If BLE is not connected, only the value is updated.

Length: 1 byte

Data: Button status code

Figure 17:
Button Status Codes

Status	Code
Released – Sample removed	0x00
Pressed – Sample inserted	0x01

5.5 Battery Level Characteristic

Battery level (0-100%) is periodically checked and the value is sent as notification upon change.

5.6 Manufacturer Name Characteristic

This characteristic belongs to the Device Information Service, which is a Bluetooth SIG service.

Type: String

Value: "ams AG"

5.7 Model Number Characteristic

This characteristic belongs to the Device Information Service, which is a Bluetooth SIG service.

Type: String

Value: Model number in the format "1.0.0".

5.8 Serial Number Characteristic

This characteristic belongs to the Device Information Service, which is a Bluetooth SIG service.

Type: String

Value: 16-character long Nordic chip ID in hexadecimal format. Chip ID is a 64-bit integer and it is unique for all units.

5.9 Hardware Revision Characteristic

This characteristic belongs to the Device Information Service, which is a Bluetooth SIG service.

Type: String

Value: Hardware version in the format "1.0.0".

5.10 Firmware Revision Characteristic

This characteristic belongs to the Device Information Service, which is a Bluetooth SIG service.

Type: String

Value: Firmware version in the format "1.0.0".

6 Device Firmware Update over BLE

The Nordic Secure Buttonless DFU Service enables updating the firmware over BLE. Updating the bootloader and the SoftDevice is also possible, but typically it is used for firmware (i.e. application) updates only. The update package is a zip file and the update can be performed using the cross-platform Nordic nRF Connect app for PC/Mac/Linux and Android/iOS devices. The new firmware is only accepted, if it is signed by the private key matching the public key that was compiled with the bootloader. Only devices with the correct bootloader are capable of performing this update.

7 Mobile Applications

ams provides iOS and Android applications, which demonstrate the functionality of LFT POC. Please refer to the following support website for more information:

ams.com/app-lateral-flow-test-point-of-care

8   Revision Information

Changes from previous version to current revision v1-00	Page
Initial version	

- Page and figure numbers for the previous version may differ from page and figure numbers in the current revision.
- Correction of typographical errors is not explicitly mentioned.

9 Legal Information

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