Document XD0506P, Revision E, 15 July 2021

Xsens DOT BLE Services Specifications

Revision	Date	By	Changes
Revision A	25 April 2020	AVY, XUF	• Initial release
Revision B	19 May 2020	XUF	• Update status definition. • Add definition of clipCountAcc and clipCountGyro.
Revision C	27 August 2020	XUF	• Add serial number in configuration service • Add power saving notification • Add 4 new payload mode • Add FL_MagIsNew status • Add synchronization message service • Add recording message service
Revision D	15 Dec 2020	XUF	• Add output rate in configuration service • Add filter profile in configuration service • Add button callback in configuration service • Add best practice for measurement service • Add StopSync message • Add GetSyncStatus message • Update best practice to start synchronization • Remove crash info service (re-design in progress)
Revision E	15 July 2021	XUF, GES	• Add supported hardware version and software version in firmware compatibility • Update the firmware changelogs URL • Add short product code in device info characteristic • Update the power off and power on options in device control characteristic • Add the custom 4 payload type in measurement service • Update the best practice for synchronization

Table of Contents

List of references

1. Xsens DOT User Manual [XD0502P]

List of Tables

List of Figures

1 Introduction

This document gives detailed Bluetooth services and characteristics specifications of Xsens DOT sensor firmware. You can refer to this document to build your applications in all platforms. Table 1 shows the Bluetooth requirements of the host device.

Table 1: Bluetooth requirements

Bluetooth requirement
• Best performance with BLE 5.0, DLE supported • Compatible with Bluetooth 4.2

To get started, read *Xsens DOT User Manual* first to understand the basic functions of the sensor. Then refer to the example code – Xsens DOT server. It is a demonstration built using Node.js in combination with Noble.

1.1 Base UUID

All attributes, i.e., services and characteristics of Xsens DOT have a UUID which is formatted as a hexadecimal number:

1517**xxxx**-4947-11E9-8646-D663BD873D93

The bold characters are those that differ between the attributes. As such, the short notation of the UUID can be used. Refer to Table 2 for the available services and its UUID.

Table 2: BLE services and characteristics

Service	UUID	Description
Configuration Service	0x1000	Sensor information and configuration settings.
Measurement Service	0x2000	Configuring and receiving data of real-time streaming.
Battery Service	0x3000	Charging status and battery level.
Message Service	0x7000	Shared service for recording and synchronization functions.

1.2 Scanning and Filtering

Xsens Technologies B.V. is an Adopter Member of Bluetooth SIG. Refer to Table 3 for the Bluetooth company identifier of Xsens.

Table 3: Xsens Bluetooth company identifier

Company	Decimal	Hexadecimal
Xsens Technologies B.V.	2182	0x0886

You can use company ID, together with the tag name ”Xsens DOT” to filter Xsens DOT sensors.

1.3 Endianness

All the members are set in little-endian.

1.4 Firmware Compatibility

All the services and characteristics are applicable to the latest firmware version v2.0.0. Table 4 shows the supported hardware, SDK and App versions regarding the firmware version.

Xsens has released the 2nd generation of Xsens DOT hereinafter as v2. Refer to the 2021-07 Product Change Notification Xsens DOT for the detailed changes.

As firmware v2.0.0 supports both v1 and v2 sensors, unless specifically mentioned, all functions in this document are applicable to v1.

Table 4: Firmware compatibility

Firmware	Hardware (Xsens DOT sensor)	SDK and App (Android & iOS)
2.0.0 (stable)	Both v1 and v2	v2021.0
1.6.0 (stable)	v1	v2020.4
1.4.0 (stable)	v1	v2020.2
1.3.0 (beta)	v1	v2020.1
1.0.0 (stable)	V1	v2020.0, v2020.1, v2020.2

Refer to the firmware changelogs for all the changes between different firmware versions.

Note – It's always recommended to use the latest firmware, SDK and App versions for new features and improvements.

2 Configuration service

Configuration service provides sensor information such as Bluetooth identity address, firmware version and serial number, as well as controlling the sensor configurations.

The UUID of this service is **0x1000** and relevant characteristics are given in Table 5.

Table 5: Characteristics of the Configuration Service

Characteristic	UUID	Description	Length	Property
Device info	0x1001	Sensor basic information	34	Read
Device control	0x1002	Sensor behavior and configurations	32	Read, Write
Device report	0x1004	Return sensor status or control command results	36	Notify

2.1 Device Info Characteristic

The device info characteristic is a 34-bytes data structure with the fields as specified in Table 6.

Table 6: Device info characteristic structure

Field name	Size	Description	Values
Address	6	Bluetooth identity address	BLE_GAP_ADDR_TYPE_PUBLIC
Version Major	1	Firmware major version	0 ~ 255, uint8
Version Minor	1	Firmware minor version	0 ~ 255, uint8
Version Revision	1	Firmware revision version	0 ~ 255, uint8
Build Year	2	Firmware build year	2019 ~ 2100, uint16
Build Month	1	Firmware build month	1 ~ 12, uint8
Build Date	1	Firmware build date	1 ~ 31, uint8
Build Hour	1	Firmware build hour	0 ~ 23, uint8
Build Minute	1	Firmware build minute	0 ~ 59, uint8
Build Second	1	Firmware build second	0 ~ 59, uint8
SoftDevice version	4	SoftDevice version	uint32_t
Serial Number	8	Serial number	uint64_t
Short Product Code	6	First 6 bytes of product code string	• "XS-T01" – Xsens DOT 1st generation sensor • "XS-T02" - Xsens DOT 2nd generation sensor

2.2 Device Control Characteristic

The device control characteristic is a 32-bytes data structure with the fields as specified in Table 7.

Table 7: Device control characteristic structure

Field name	Size	Description	Values
Visit Index	1	One-byte bitmask. b0: Identifying b1: Power off b2: Power saving timeout b3: Tag name b4: Output rate b5: Filter profile index	Set the bit to 1 to enable the corresponding function. Set the bit to 0 to ignore.
Identifying	1	Sensor will be identified if it's set to "0x01". The sensor LED will fast blink 8 times and then a short pause in red, lasting for 10 seconds.	0x01: identify the sensor
Power off and power on options	1	Power off – shut down the sensor. Power on options – This setting is only available in Xsens DOT v2 sensor. v2 sensor can always be powered on by pressing the power button for 2 seconds. Additionally, it can also be turned on by USB plug in. This function is disabled by default and it can be enabled by setting the b1 to "1".	• b0: Set '1' to power off the sensor • b1: Set '1' to enable the v2 sensor to be powered on by USB plug in. Set '0' to disable it. • b2 – b7: reserved Set b0 to '1' will ignore other bits in this field.
Power saving timeout X (minute)	1	Timeout threshold that sensor goes to power saving mode in advertisement mode. Set to 0 if you want to disable power saving in advertisement mode.	0 ~ 30, default value 10
Power saving timeout X (second)	1		0 ~ 60, default value 0
Power saving timeout Y (minute)	1	Timeout threshold that sensor goes to power saving mode in connection mode. Set to 0 if you want to disable power saving in connection mode.	0 ~ 30, default value 30
Power saving timeout Y (second)	1		0 ~ 60, default value 0
Device Tag length	1	Length of tag name. Ignore the write operation for invalid length.	0 ~ 16
Device Tag[1]	16	Device tag name	Default value "Xsens DOT"
Output rate	2	Data output rate (Hz) for real-time streaming and recording. It cannot be changed after measurement or synchronization start.	1, 4, 10, 12, 15, 20, 30, 60, 120 • Default value 60

[1] Don't use special numeric for tag name, such as /\:, in case of potential error in host applications.

			- 120 is only available for recording.
Filter profile index	1	Index of the filter profile. Use the index to get or set the active filter profile for real-time streaming and recording. It cannot be changed after measurement or synchronization start.	Refer to Table 8 for the index and information of filter profiles. Refer to section 3.2 in User manual for detailed information.
Reserved	5	Reserved for future use	0

Note - the bold fields are saved in external flash.

Table 8: Filter profile index and information

Index	Property	Name	Name length	Description
0	Public	General	7	Default for general human motions
1	Public	Dynamic	7	For fast and jerky human motions like sprinting.

2.3 Device Report Characteristic

The device report characteristic is a 36-bytes data structure. Based on the command sent from the device control characteristic, or the operations applied on the sensor, the sensor will send out specific report to inform the central device. The following sections list out 3 different types of report. The structure of each report is also specified. Ignore the unused bytes.

2.3.1 Power off

Sensor will send out this report when it is powered off by following methods:

1. Power button is pressed over 3s
2. Receive power off command from central as described in Table 7.
3. Battery level is lower than 2%

Table 9: Power off structure

Field name	Size	Description	Values
Type	1	Sensor is powered off.	1
-	35	Unused	-

2.3.2 Power saving

Sensor will send out this report when entering power saving mode in advertisement or connection mode.

Table 10: Power saving structure

Field name	Size	Description	Values
Type	1	Sensor is in power saving mode.	4
-	35	Unused	-

2.3.3 Button callback

If there is a single click on the power button during connection, sensor will send out this report with a sensor timestamp. This function is called as "Button callback".

When the pressing time is 10~800ms, it is judged as a valid single click. The timestamp is from sensor's local clock and independent of synchronization timestamp.

Table 11: Button callback structure

Field name	Size	Description	Values
Type	1	Detection of a single click	5
Length	1	The length of the timestamp	4: 4 bytes timestamp (default) 8: 8 bytes timestamp
Timestamp	4 or 8	Timestamp when the power button is pressed. Unit is millisecond.	
-	30 or 26	Unused	-

3 Measurement service

Measurement service enables the start and stop of the measurement on the sensor, as well as setting payload modes and receiving the measurement data.

The UUID of this service is **0x2000** and relevant characteristics are given in Table 12.

Table 12: Characteristics of the Measurement Service

Characteristic	UUID	Description	Length	Property
Control	0x2001	Control the start/stop and payload mode of the measurement.	3	Read, Write
Long payload length	0x2002	Return the data of payload modes that have payload length higher than 40 bytes.	63	Notify
Medium payload length	0x2003	Return the data of payload modes that have payload length between 21 to 40 bytes.	40	Notify
Short payload length	0x2004	Return the data of payload modes that have payload length between 0 to 20 bytes.	20	Notify
Magnetic field mapper	0x2005	Not for public use	-	-
Orientation reset control	0x2006	Reset or revert the heading.	2	Read, Write
Orientation reset status	0x2007	Heading reset result	1	Read
Orientation reset data	0x2008	Not for public use	-	-

3.1 Control Characteristic

The control characteristic is a 3-bytes data structure with the fields as specified in Table 13.

Note - Enable BLE notification to get the measurement data for real-time streaming before setting the control characteristic.

Table 13: Control characteristic structure

Field Name	Size	Description	Values
Type	1	Type of the control target	1: measurement Others are invalid value
Action	1	Start or stop the measurement or get the status of the measurement.	0: stop, or measurement is stopped 1: start, or measurement is started
Payload mode	1	Set the payload mode or get the current payload mode. Based on payload length, each measurement type will use medium or short payload length characteristics for notification. Refer to section 3.2 and 3.4 for the structure of each payload mode.	1: High Fidelity (with mag) [2] 2: Extended (Quaternion) 3: Complete (Quaternion) 4: Orientation (Euler) 5: Orientation (Quaternion) 6: Free acceleration 7: Extended (Euler) 16: Complete (Euler) 17: High Fidelity[3] 18: Delta quantities (with mag) 19: Delta quantities 20: Rate quantities (with mag) 21: Rate quantities 22: Custom mode 1 23: Custom mode 2 24: Custom mode 3 25: Custom mode 4[4]

Note - the **bold** fields are saved in external flash.

[2] High Fidelity (with mag) payload mode can only be parsed through the SDK
[3] High Fidelity payload mode can only be parsed through the SDK
[4] Custom mode 4 payload mode can only be parsed through the SDK

3.2 Long Payload Length Characteristic

Long payload length characteristic will return the data of payload mode that has the payload length higher than 40 bytes.

Based on the selected payload mode in control characteristic, the structure of long payload characteristic is specified in Table 14. Refer to Table 17 for the definition and format of each measurement data. The data transmission order is the data structure order listed in the table. Unused bytes are all set to 0x00.

Table 14: Long payload length modes

Payload mode	Total Size	Data structure
Custom mode 4	51	This mode contains timestamp, inertial data in high fidelity mode, quaternion, magnetic field data and status. It can only be parsed through the SDK. So please use this mode through the SDK.

3.3 Medium Payload Length Characteristic

Medium payload length characteristic will return the data of payload mode that has the payload length between 21 and 40 bytes.

Based on the selected payload mode in control characteristic, the structure of medium payload characteristic is specified in Table 15Table 14. Refer to Table 17 for the definition and format of each measurement data. The data transmission order is the data structure order listed in the table. Unused bytes are all set to 0x00.

Table 15: Medium payload length modes

Payload mode	Total Size	Data structure
Extended (Quaternion)	36	• Timestamp • Quaternion • Free acceleration • Status • clipCountAcc • clipCountGyr
Complete (Quaternion)	32	• Timestamp • Quaternion • Free acceleration
Extended (Euler)	32	• Timestamp • Euler • Free acceleration • Status • clipCountAcc • clipCountGyr
Complete (Euler)	28	• Timestamp • Euler • Free acceleration
High Fidelity (with mag)	35	This mode contains timestamp, inertial data in high fidelity mode, magnetic field data and status. It can only be parsed through the SDK. So please use this mode through the SDK.

High Fidelity	29	This mode contains timestamp, inertial data in high fidelity mode and status. It can only be parsed through the SDK. So please use this mode through the SDK.
Delta quantities (with mag)	38	• Timestamp • dq • dv • Magnetic field
Delta quantities	32	• Timestamp • dq • dv
Rate quantities (with mag)	34	• Timestamp • Acceleration • Angular velocity • Magnetic field
Rate quantities	28	• Timestamp • Acceleration • Angular velocity
Custom mode 1	40	• Timestamp • Euler • Free acceleration • Angular velocity
Custom mode 2	34	• Timestamp • Euler • Free acceleration • Magnetic field
Custom mode 3	32	• Timestamp • Quaternion • Angular velocity

3.4 Short Payload Length Characteristic

Short payload length characteristic will return the data of payload mode that has the payload length lower than 20 bytes.

Based on the selected payload mode in control characteristic, the structure of long payload characteristic is specified in Table 16. Refer to Table 17 for the definition and format of each measurement data. The data transmission order is the data structure order listed in the table. Unused bytes are all set to 0x00.

Table 16: Short payload length modes

Payload mode	Total Size	Data structure
Orientation (Euler)	16	• Timestamp • Euler
Orientation (Quaternion)	20	• Timestamp • Quaternion
Free acceleration	16	• Timestamp • Free acceleration

3.5 Measurement Data

This section explains the definition and format for each measurement data in medium and short payload length characteristics. Refer to chapter 4 in *Xsens DOT User Manual* for more details about each data.

Table 17: Measurement data

Data	Size	Description	Format
Timestamp	4	Timestamp on the sensor in microseconds.	
Quaternion	16	The orientation expressed as a quaternion.	w,x,y,z, IEEE-754 32-bit floating point
Euler angles	12	The orientation expressed as Euler angles, degree.	x,y,z, IEEE-754 32-bit floating point
Free acceleration	12	Acceleration in local earth coordinate and the local gravity is deducted, m/s^2	x,y,z, IEEE-754 32-bit floating point
dq	16	Orientation change during a time interval.	w,x,y,z, IEEE-754 32-bit floating point
dv	12	Velocity change during a time interval, m/s.	x,y,z, IEEE-754 32-bit floating point
Acceleration	12	Calibrated acceleration in sensor coordinate, m/s^2.	x,y,z, IEEE-754 32-bit floating point
Angular velocity	12	Rate of turn in sensor coordinate, dps.	x,y,z, IEEE-754 32-bit floating point
Magnetic field	6	Magnetic field in sensor coordinate, a.u.	x,y,z, fixed point
Status	2	See section 3.5.1	unsigned short
clipCountAcc	1	Count of ClipAcc in status	unsigned integer
clipCountGyr	1	Count of ClipGyr in status	unsigned integer

3.5.1 Status definition

Data (Bit mask)	Abbr.	Description
0x0001	FL_ClipAccX	Accelerometer is out of range in x-axis
0x0002	FL_ClipAccY	Accelerometer is out of range in y-axis
0x0004	FL_ClipAccZ	Accelerometer is out of range in z-axis
0x0008	FL_ClipGyrX	Gyroscope is out of range in x-axis
0x0010	FL_ClipGyrY	Gyroscope is out of range in y-axis
0x0020	FL_ClipGyrZ	Gyroscope is out of range in z-axis
0x0040	FL_ClipMagX	Magnetometer is out of range in x-axis
0x0080	FL_ClipMagY	Magnetometer is out of range in y-axis
0x0100	FL_ClipMagZ	Magnetometer is out of range in z-axis
0x0200	FL_MagIsNew	Magnetometer sample in this data packet is updated. In DOT the magnetometer is sampled at 60Hz so this bit should always be set if the output rate is 60Hz.

For example, if status is 0x0012, it means accelerometer is out of range in y-axis and gyroscope is out of range in y-axis for this data packet.

3.6 Orientation Reset Control Characteristic

Orientation reset allows the user to align the orientation outputs among all sensors and with the object(s) they are connected to. Only heading reset is available for now. The heading reset or revert must be executed during the measurement. Heading reset is maintained between connection/disconnection or different measurements but will be lost after the sensor reboots. After reset the heading, a revert is required before conducting a new reset.

The orientation reset control characteristic a 2-bytes data structure with the fields as specified in Table 18.

Table 18: Orientation reset control characteristic structure

Field name	Size	Description	Values
Type	2	Control to reset or revert the heading.	0x0001: Reset heading 0x0007: Revert heading to default 0x0008: Default status

3.7 Orientation Reset Status characteristic

Table 19: Orientation reset status structure

Field name	Size	Description	Values
ResetResult	1	The result of heading reset	0: Fail 1: Success

3.8 Best Practices for Measurement Service

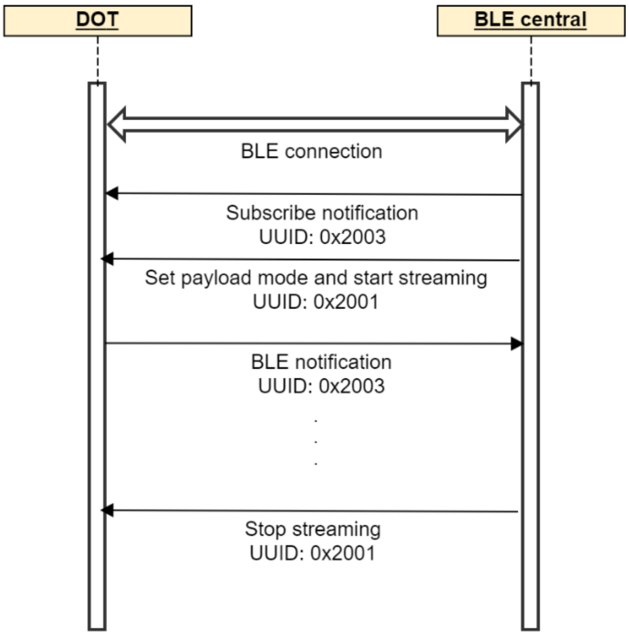

Figure 1: Best practice to start a measurement

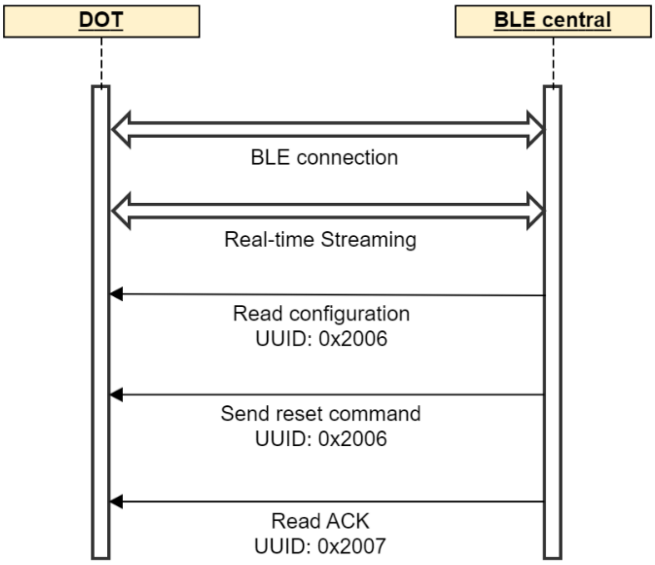

Figure 2: Best practice to reset the heading

4 Battery Service

This service provides battery information such as battery level and charging status. The sensor will periodically read the fuel gauge to give an up-to-date value. This service will explicitly notify the battery level when battery level percentage changes.

The UUID of this service is **0x3000** and relevant characteristics are given in Table 12.

Table 20: Characteristics of the Battery Service

Characteristic	UUID	Description	Length	Property
Battery	0x3001	Battery level and charging status	2	Read, Notify

4.1 Battery Characteristic

The battery characteristic is a 2-bytes data structure with the fields as specified in Table 21.

Table 21: Battery characteristic structure

Field name	Size	Description	Values
Battery level	1	Battery level in percentage	0~100
Charging status	1	Charging status of the battery	0: Not charging 1: Charging

4.2 Best Practice for Battery Service

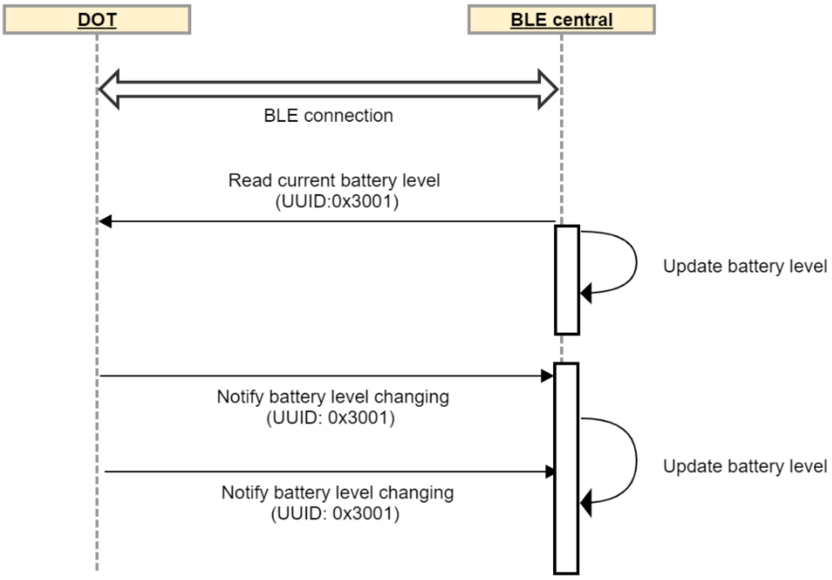

Figure 3: Best practice of battery service

5 Message Service

Message service is a shared service for recording and synchronization functions.

The UUID of this service is **0x7000** and relevant characteristics are given in.

Table 22: Characteristics of the Battery Service

Characteristic	UUID	Description	Length	Property
Control	0x7001	Manage control messages	160	Write
Acknowledge	0x7002	Manage acknowledge messages	160	Read
Notification	0x7003	Manage notification message	160	Notify

5.1 Message Structure

The communication of recording and synchronization functions with Xsens DOT sensors is done by messages which are built according to a standard structure. The message has a maximum of 157 data bytes.

A DOT message contains the following fields:

MID	LEN	DATA	CHECKSUM

Table 23: construction of message

Field	Field width	Description
MID	1 byte	Message Identifier
LEN	1 byte	Specifies the number of data bytes in the DATA field
DATA	0-157 bytes	Data bytes
CHECKSUM	1 byte	Checksum of message

Message Identifier (MID)
This message field identifies the type of message.

Table 24: Message ID

MID	Description
0x01	Recording Message
0x02	Synchronization message

Length (LEN)
Specifies the number of data bytes in the DATA field.

Data (DATA)
This field contains the data bytes. The data is always transmitted in little-endian format.

Checksum
This field is used for communication error-detection. If all message bytes are summed and the lower byte value of the result equals zero, the message is valid and it may be processed. The checksum value of the message should be included in the summation.

5.2 Recording Message

With recording function, sensor data can be stored in internal storage and exported for post process after the measurement. Refer to section 3.3.3 in *Xsens DOT User Manual* for more information about recording function.

MID of recording messages is 0x01. DATA of recording message contains two fields: recording ID (ReID) and recording DATA (ReDATA).

A recording message contains the following fields:

		DATA		
MID(0x01)	LEN	ReID	ReDATA	CHECKSUM

Recording ID (ReID)
This field identifies different recording messages. For a complete listing of all possible recording messages see section 5.2.2, 5.2.3 and 5.2.4.

Recording DATA (ReDATA)
This field contains the recording data bytes. The interpretation of the recording data bytes is recording message specific, i.e., depending on the ReID value the meaning of the ReDATA bytes is different.

5.2.1 Recording message usage

After sending a recording control message with a certain ReID, check the acknowledge (ACK) right after it. Otherwise, this acknowledge will be overwritten by the acknowledge of the next message.

Some recording message will be replied with a notification message with a ReID value that is increased. Depending on the message type, the notificaiton message can have a data field (no fixed length) or not. If nothing is specified, the data field does not exist.

Some messages have the same ReMID and the meaning differs depending on its message service characteristics. For example, the ReMID of control message stop recording (StopRecording) is the same as the notification message that recording stopped (RecordingStopped). The difference between the two messages is that they use different message characteristices.

Example
Request the recording status:

Sending message:
    GetState = 0x010102FC
Check acknowledge:
    Acknowledge = 0x01030106 02F30000 00000000 ... 00000000

Example
Start a 30 min timed recording

Sending message:

StartRecording = 0x010740DF503B5B0807E0

Check acknowledge:

Acknowledge = 0x01090100 40DF503B 5B0807DD 00000000 … 00000000

Example

Stop a timed recording:

Sending message:

StopRecording = 0x010141BD

Check acknowledge:

Acknowledge = 0x01030100 41BA0000 00000000 00000000 … 00000000

Example

Request 1st file information:

Sending message:

RequestFileInfo = 0x010260019C

Check acknowledge:

Acknowledge = 0x01040100 60019900 00000000 00000000 … 00000000

Receiving notification:

Notification =
0x0181616F 63655280 00000000 01B8C633 … 00000000
0x0101629C 00000000 00000000 00000000 … 00000000

Example

Select export data with following data quantities:

1. Timestamp
2. Quaternion
3. dq
4. dv
5. Calibrated angular velocity
6. Calibrated acceleration
7. Calibrated mag
8. Status

Sending message:

SelectExportData = 0x01097400010506070809 0A54

Receiving notification:

Notification = 0x010B0100 74000105 06070809 0A510000 … 00000000

Example

Request 7th file data:

Sending message:

RequestFileData = 0x0102700786

Check acknowledge:

Acknowledge = 0x01040100 70078300 00000000 00000000 … 00000000

Receiving notification:

```
Notification =
0x01557100 00000075 A766A81A 3D643EFF ... 00000000 00000000
0x01557101 00000090 E866A84B A7673E67 ... 00000000 00000000
...
```

5.2.2 Recording control messages

GetState

ReID	0x02
ReDATA	n/a
Direction	To sensor
Valid in	Any state

Request sensor’s recording state. Check acknowledge to get the result.

EraseFlash

ReID	0x30
ReDATA	EraseUTC (4 bytes)
Direction	To sensor
Valid in	Idle state

Request to clear all the recording data space, other flash space will not be affected. A **StoreFlashInfoDone** notification will be sent to host if recording flash erase is completed.

EraseUTC
The erase start time that contains the timestamp expressed as the UTC time in seconds.

StartRecording

ReID	0x40	
ReDATA	StartUTC (4 bytes)	RecordingTime (2 bytes)
Direction	To sensor	
Valid in	Idle state	

Start recording message. Recording will automatically stop in the following situations:

- power button is pressed over 1 second
- time is up for timed recording
- flash memory is over 90%

RecordingStopped notification will be sent to the host once the recording stops.

StartUTC
The recording start time that contains the timestamp expressed as the UTC time in seconds.

RecordingTime
The time setting value of a timed recording and the unit is second. Don't set a timer that exceeds the maximum recording time (88 min = 5280 sec). Set RecordingTime to 0xFFFF if you want a normal recording without timer.

StopRecording

ReID	0x41
ReDATA	n/a
Direction	Both
Valid in	Recording state

Stop recording.

RequestRecordingTime

ReID	0x42
ReDATA	n/a
Direction	To sensor
Valid in	Recording state

Request the recording time since recording started. **RecordingTime** notification will be sent to host with recording time information.

RequestFlashInfo

ReID	0x50
ReDATA	n/a
Direction	To sensor
Valid in	Idle state

Request recording flash information. **ExportFlashInfo** notification will be sent to host with flash information. **ExportFlashInfoDone** notification will be sent if the flash information has been sent completely.

RequestFileInfo

ReID	0x60
ReDATA	FileIndex (1 byte)
Direction	To sensor
Valid in	Idle state

Request recording file information by FileIndex. **ExportFileInfo**
notification will be sent to host with the requested recording file information.

ExportFileInfoDone notification will be sent if the file information has been sent completely.

FileIndex
Index of the recording files. Starts from 0x01 and maximum up to 0xFE. You can get total file number and file sizes from **ExportFlashInfo** notification.

`RequestFileData`

ReID	0x70
ReDATA	FileIndex (1 byte)
Direction	To sensor
Valid in	Idle state

Request recording file data based on FileIndex. Recording file data packets will be sent to host via **`ExportFileData`** notification. **`ExportFileDataDone`** notification will be sent if all the file data has been sent.

`StopExportData`

ReID	0x73
ReDATA	n/a
Direction	Both
Valid in	Export recording data

Use this message to stop data exporting.

`SelectExportData`

ReID	0x74
ReDATA	SelectedData
Direction	To sensor
Valid in	Idle state

Configure export data options. Set byte array if you want to export multi-quantites. This message should be sent before **`RequestFileData`**. Otherwise, the default data byte array [0x00, 0x04, 0x07, 0x08] will be set.

SelectedData
See the table for the available data quantity and the corresponding value of SelectedData. Refer to chapter 4 in *Xsens DOT User Manual* for the meanings of data and section 3.5 for data format.

Table 25: Available data when exporting

Data quantity	SelectedData
Timestamp	0x00
Quaternion	0x01
Euler Angles	0x04
dq	0x05
dv	0x06
Acceleration	0x07
Angular Velocity	0x08
Mag Field	0x09
Status	0x0a
clipCountAcc	0x0b
clipCountGyro	0x0c

Note that free acceleration is not provided in this firmware. Refer to this base article to calculate free acceleration from quaternion and dv.

Retransmission

ReID	0x75
ReDATA	RetransDataNumber (4 byte)
Direction	To sensor
Valid in	Export data state

Retransmit all the data from the RetransDataNumber packet.

RetransDataNumber
Packet Counter of the retransmit data packet.

5.2.3 Recording acknowledge message

ReID	0x01		
ReDATA	Result (1 byte)	Control message ReID	Control message ReDATA
Direction	To host		

Acknowledge (ACK) is the receipt of a control message. ReDATA contains the Result in 1 byte and the control message DATA from host to clarify which message the ACK is responding to.

Result
Indicates the receiving status of a control message, or the sensor states when receiving the message.

Table 26: Recording ACK Results

Result	Description	Details
0x00	Success	Control messages write success
0x02	InvalidCmd	Invalid command
0x03	FlashProcessBusy	Flash is occupied by other process
0x06	IdleState	Idle state
0x30	OnErasing	Erasing internal storage
0x40	OnRecording	In recording state
0x50	OnExportFlashInfo	Exporting flash information
0x60	OnExportRecordingFileInfo	Exporting recording file information
0x70	OnExportRecordingFileData	Exporting recording data

Control message ReID
ReID of the control message.

Control message ReDATA
ReDATA of the control message.

5.2.4 Recording notification messages

Notifications of recording control messages. A callback is required to handle notifications.

FlashProcessBusy

ReID	0x03
ReDATA	n/a
Direction	To host

Flash is occupied by other process. Wait a while and send the control message again.

StoreFlashInfoDone

ReID	0x33 0x31
ReDATA	n/a
Direction	To host

Recording flash erase is completed.

FlashFull

ReID	0x34
ReDATA	n/a
Direction	To host

Recording flash space is full.

InvalidFlashFormat

ReID	0x35
ReDATA	n/a
Direction	To host

Recording flash format is invalid. Current firmware version doesn’t support the flash format. Use **EraseFlash** to reset the flash format.

RecordingStopped

ReID	0x41
ReDATA	n/a
Direction	Both

Recording stopped.

RecordingTime

ReID	0x43		
ReDATA	StartUTC (4 bytes)	TotalRecordingTime (2 bytes)	RemainingRecordingTime (2 bytes)
Direction	To host		

StartUTC
Recording start UTC and unit is second.

TotalRecordingTime
Total recording time of a timed recording. Unit is second. 0xFFFF for normal (non-timed) recording.

RemainingRecordingTime
Remaining time of a timed recording. Unit is second. 0xFFFF for normal (non-timed) recording.

ExportFlashInfo

ReID	0x51
ReDATA	Flash header file information (128 bytes)
Direction	To host

A simple recording file system is created to manage the recording files. Following table shows the structure of the recording flash. It consists of a header file and the recording files.

Table 27: Structure of recording flash

Header file (4 kB)	1st recording file	2nd recording file	…

Recording flash information is preserved in the header file. See the table below for header file structure.

Table 28: Header file structure

Field		Field width	Description
Header	Magic number	4 bytes	0x466C6173
	Header size	4 bytes	0X80, header size is 128 bytes
	Revision	2 bytes	Current revision number is 0.1 (decimal)
	Flash erase/creation UTC	4 bytes	Unit: second
	Flash size	4 bytes	Unit: byte
	Reserved	110 bytes	Reserved byte is set to 0xFF
File indicator		0~3968 bytes	Indication of recording file number and size

See the table below for the structure of file indicator.

Table 29: Structure of file indicator

Field	Field width	Description
1st file header	1 byte	file header, 0xEE represents a recording file and 4 kB file header
1st file size	Based on file size	Rough estimate of file size. Each 0xCC represents 228 kB file size
2nd file header	1 byte	0xEE
2nd file size	Based on file size	0xCC…
…		

Unused bytes in file indicator are set to 0xFF. File indicator are all 0xFF bytes if there is no recording file in the flash.

You can get the file number and rough file size through file indicator. For example, 0xCCEECCEEEEFF…FF means that there are 2 files in the recording flash:

- The first file has a rough size of 232kB (4kB +228kB)
- The second file has a rough size of 460kB (4kB +228kB*2)

This notification may response with multiple messages based on the actual length of the header file, with each message contains 128 bytes ReDATA. It stops when there is all 0xFF values in next message.

If you get the mess code, or there is no information in the message, it means the flash structure is invalid. Erase the flash to reset it.

ExportFlashInfoDone

ReID	0x52
ReDATA	n/a
Direction	To host

Recording flash information export is completed.

ExportFileInfo

ReID	0x61
ReDATA	File header space information (128 bytes)
Direction	To host

Refer to the table below for file structure.

Table 30: Structure of the file

Header space (4 kB)	Data

Reocridng file information is preserved in header space.

Table 31: Structure of header space

Field		Field width	Description
Header	Magic number	4 bytes	0x5265636F
	Header size	4 bytes	0X80, header size is 128 bytes
	Revision	2 bytes	Current revision number is 0.1 (decimal)
	Start recording UTC	4 bytes	Unit: second
	Total recording time	2 bytes	Unit: second
	Reserved	112 bytes	Reserved byte is set to 0xFF
Reserved		3968 bytes	-

ExportFileInfoDone

ReID	0x62
ReDATA	n/a
Direction	To host

Recording file information export is completed.

NoRecordingFile

ReID	0x63
ReDATA	n/a
Direction	To host

There is no recording file (with this FileIndex).

ExportFileData

ReID	0x71	
ReDATA	DataNumber (4 bytes)	ExportedData
Direction	To host	

Export the file data based on the FileIndex and SelectedData. Refer to section 3.5 for the format of each data. Each notification contains one data packet with the following ReDATA fields:

DataNumber
Data packet counter, starts from 0.

ExportedData
Data packet base on SelectedData configuration.

ExportFileDataDone

ReID	0x72
ReDATA	n/a
Direction	To host

Recording data export is completed.

ExportDataStopped

ReID	0x73
ReDATA	n/a
Direction	Both

ExportFlieDataInvalid

ReID	0x76	
ReDATA	DataNumber (4 bytes)	ExportedData
Direction	To host	

Invalid data packet due to internal data checksum or preamble check fail.

5.2.5 Best practice for recording

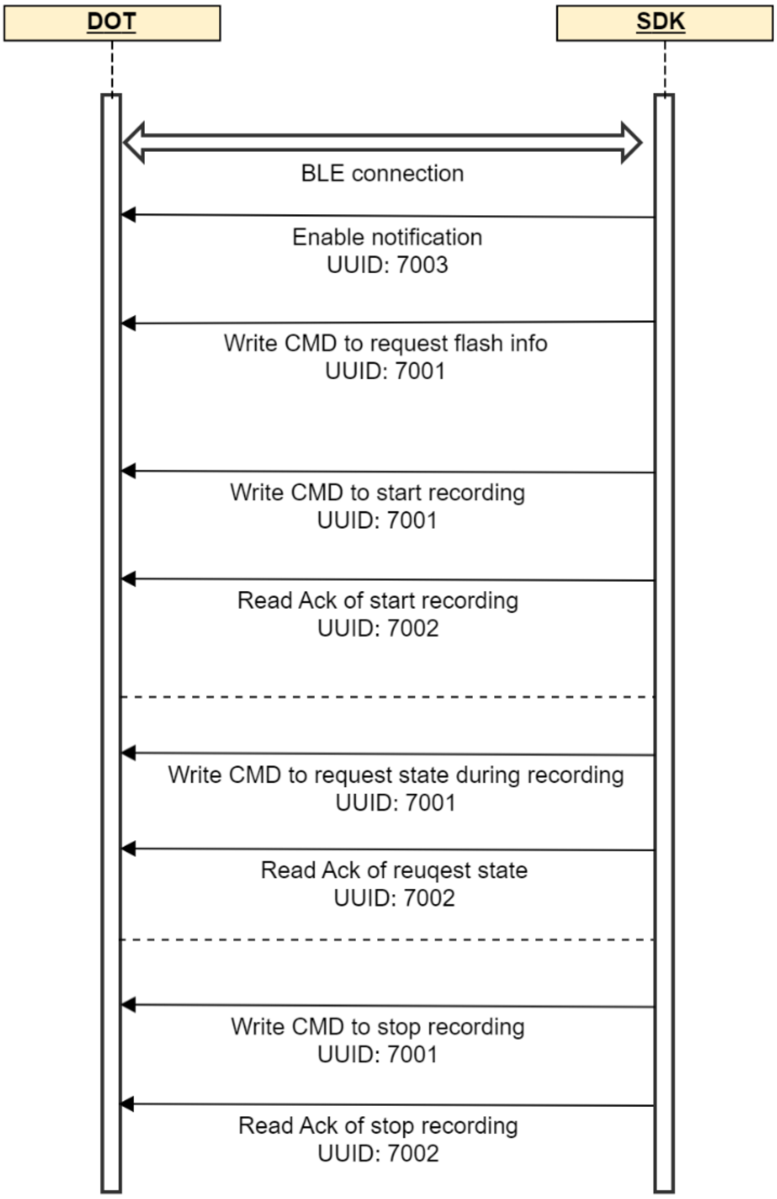
DOT
SDK
BLE connection
Enable notification
UUID: 7003
Write CMD to request flash info
UUID: 7001
Write CMD to start recording
UUID: 7001
Read Ack of start recording
UUID: 7002
Write CMD to request state during recording
UUID: 7001
Read Ack of reuqest state
UUID: 7002
Write CMD to stop recording
UUID: 7001
Read Ack of stop recording
UUID: 7002

Figure 4: Best practice to start and stop recording

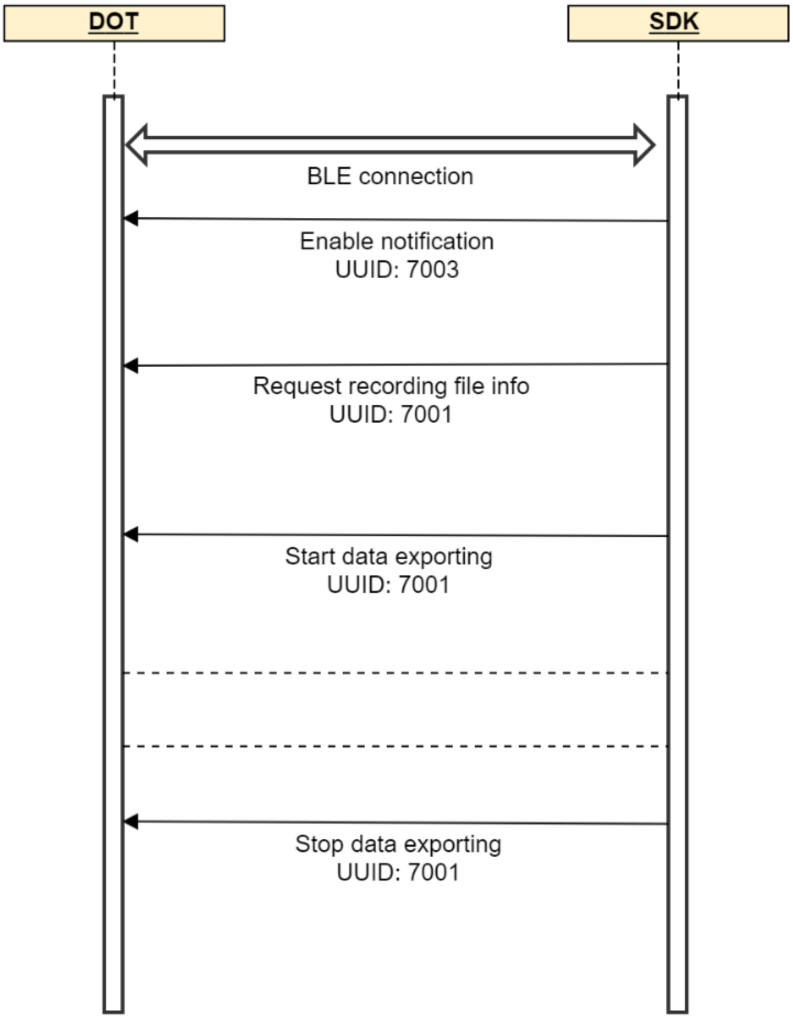

Figure 5: Best practice to export recording files

5.3 Synchronization Message

All sensors will be time-synced with each other to a common sensor time base after synchronization. Refer to section 3.3.4 in *Xsens DOT User Manual* for more information.

MID of synchronization messages is 0x02. DATA of synchronization message contains the sync ID (SyID) and sync DATA (SyDATA).

A synchronization message contains the following fields:

		DATA		
MID(0x02)	LEN	SyID	SyDATA	CHECKSUM

Sync ID (SyID)
This field identifies different synchronization messages. For a complete listing of all possible synchronization messages see section 5.3.2, 5.3.3 and 5.2.4.

Sync DATA (SyDATA)
This field contains the synchronization data bytes. The interpretation of the synchronization data bytes is synchronization message specific, i.e., depending on the SyID value the meaning of the SyDATA bytes is different.

5.3.1 Synchronization message usage

Example
Get synchronization status.

Sending message:
    GetSyncStatus = 0x020108F5
Get notification:
    SyncStatus = 0x02025109A2 or 0x02025104A7

Example
Start synchronization. Root node MAC address is D4:CA:6E:F1:69:3D

Sending message:
    StartSync = 0x0207013D69F16ECAD453
Check acknowledge:
    Acknowledge = 0x02020300 F9

Example
Stop synchronization.

Sending message:
    StopSync = 0x020102FB
Get notification:
    StopSyncResult = 0x02025000AC

5.3.2 Synchronization control messages

StartSync

SyID	0x01
SyDATA	Root node MAC address (6 bytes)
Direction	To sensor
Valid in	Connection state

Start the synchronization. Refer to section 5.3.5 for the best practice to start synchronization.

Root node MAC address
Root node can be any of the sync sensors. If the MAC address is AA:BB:CC:DD:EE:FF, then the SyDATA should be 0xFF, 0xEE, 0xDD, 0xCC, 0xBB, 0xAA.

StopSync

SyID	0x02
SyDATA	-
Direction	To sensor
Valid in	Synced state

Stop the synchronization. **StopSyncResult** notification will be sent to let the host know if the StopSync is successful or not.

GetSyncStatus

SyID	0x08
SyDATA	-
Direction	To sensor
Valid in	Connection state

Check if the sensor is already synced or not. **SyncStatus** notification will be sent to host with the sync status.

5.3.3 Synchronization acknowledge message

SyID	0x01		
SyDATA	Result (1 byte)	Control message SyID	Control message SyDATA
Direction	To host		

Acknowledge (ACK) is the receipt of a control message. SyDATA contains the Result in 1 byte and the control message DATA from host to clarify which message the ACK is responding to.

Result
Indicates the result of the synchronization after re-connection with the sensor.

Table 32: Synchronization ACK Results

Result	Description	Details
0x00	Success	Synchronization success
0x05	NoEnoughSample	Sync failed for not enough data samples
0x07	SkewTooLarge	Sync failed for estimated skew too large
0x08	StartingTimingError	Sync failed for start time error
0x09	Unstarted	Sync is not started

Control message SyID
SyID of the control message.

Control message SyDATA
SyDATA of the control message.

5.3.4 Synchronization notification message

Notifications of synchronization control messages. A callback is required to handle notifications.

StopSyncResult

SyID	0x50
SyDATA	Result (1byte)
Direction	To host

Result
The result of stop sync command. 0x00 means success. 0x01 means failed.

SyncStatus

SyID	0x51
SyDATA	SyncStatus (1byte)
Direction	To host

SyncStatus
The sync status of the sensor. 0x04 means synced. 0x09 means un-synced.

5.3.5 Best practice for synchronization

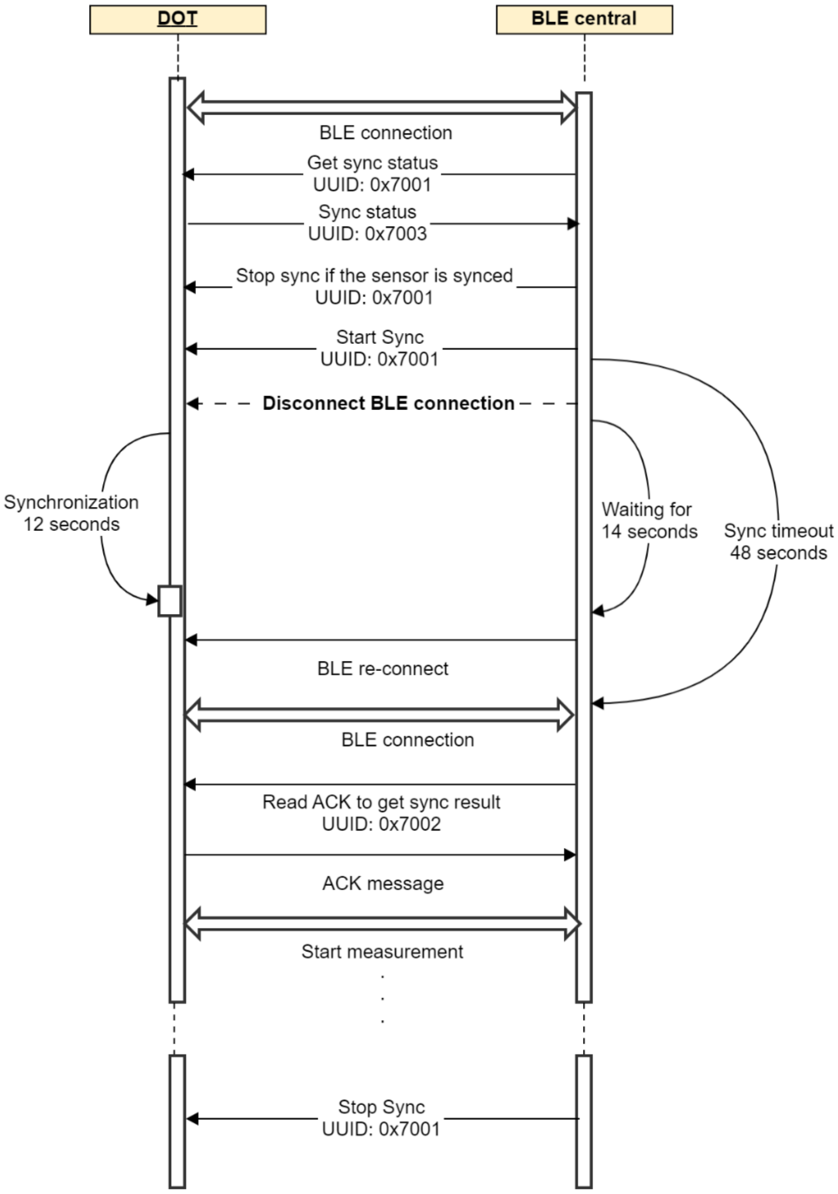

Figure 6: Best practice to start synchronization

Before starting the synchronization, check the synchronization status of the target sensors and make sure they are not synced. Stop the synced sensor before starting a new synchronization to prevent error status.

Set the output rate and filter profile before starting the synchronization. Since the sensor will enter measurement mode right after the sync succeeds so it’s not possible to change it after sync.

Disconnect the sensors after sending start sync command to allow scanners to receive the data from the root sensor. It will take about 12 seconds to finish the sync period. Reconnect to the sensors again after 14s and retry if connection fails. Read the acknowledge right after the reconnection to get the synchronization result. If the synchronization is successful for all sensors, then you can start the measurement. If any of the sensors fails in synchronization, you can continue with the successful sensors or stop the synchronization for all the involved sensors and try again.

5.4 Message Reference Listing

5.4.1 Recording messages (section 5.2)

MID	ReID	Message	Direction	Description
0x01	0x01	ACK	To host	Acknowledge message
	0x02	GetState	To sensor	Request sensor recording state
	0x03	FlashProcessBusy	To host	Flash is occupied by other process
	0x30	EraseFlash	To sensor	Request to clear all the recording data space
	0x33	StoreFlashInfoDone	To host	Flash information has been updated
	0x34	FlashFull	To host	Recording flash space is full
	0x35	InvalidFlashFormat	To host	Recording flash format is invalid
	0x40	StartRecording	To sensor	Start recording
	0x41	StopRecording	Both	Stop recording or recording stopped
	0x42	RequesetRecordingTime	To sensor	Request recording time
	0x43	RecordingTime	To host	Recording time values
	0x50	RequetFlashInfo	To sensor	Request recording flash information
	0x51	ExportFlashInfo	To host	Export flash information
	0x52	ExportFlashInfoDone	To host	Export flash information done
	0x60	RequestFileInfo	To sensor	Request recording file information by FileIndex
	0x61	ExportFileInfo	To host	Export file information
	0x62	ExportFileInfoDone	To host	Export file information done
	0x63	NoRecordingFile	To host	No recording file (with this FileIndex).
	0x70	RequestFileData	To sensor	Request recording file data based on FileIndex
	0x71	ExportFileData	To host	Export recording file data based on FileIndex
	0x72	ExportFileDataDone	To host	Export file data done
	0x73	StopExportData	Both	Stop export file data or export stopped
	0x74	SelectExportData	To sensor	Configure export data options
	0x75	Retransmission	To sensor	Retransmit all the data from the RetransDataNumber packet
	0x76	ExportFileDataInvalid	To host	Invalid data packet due to internal data checksum or preamble check fail

5.4.2 Synchronization messages (section 5.3)

MID	SyID	Message	Direction	Description
0x02	0x01	StartSync	To sensor	Start synchronization
	0x01	ACK	To host	Acknowledge message
	0x02	StopSync	To sensor	Stop synchronization
	0x08	GetSyncStatus	To sensor	Get synced or un-synced status
	0x50	StopSyncResult	To host	Notification of stop sync result
	0x51	SyncStatus	To host	Notification of sync status