Bosch Connected Devices and Solutions GmbH
SCD110 BLE Communication Protocol v1.0

SCD110 – Sense Connect Detect

BLE Communication Protocol – Version 1.0

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1 General Information

SCD110 is a multi-sensor IoT device with four sensors. It is developed for condition monitoring and predictive maintenance applications in industrial area. In this document, SCD refers to the SCD110 device.

SCD110 can communicate over Bluetooth Low Energy (BLE). This document is the BLE Communication Protocol which explains the details about the BLE interface of the device. It presents how to setup the device and get data over BLE.

This document refers to *SCD BLE Interface Specification* version **0x07**.

This document refers to SCD110 firmware version v01.03.00.

In this document the “peripheral device” refers to the SCD and the “central device” refers to the device that connects to the SCD over BLE, which can be a smartphone, Gateway or PC.

Please ensure that the SCD110 is working correctly by reading the operating instructions document carefully before using the device in your application.

In this document BCDS refers to Bosch Connected Devices and Solutions GmbH.

1.1 Definition of special notices

Note: Indicates important notes, information, tips about the communication of the device. Please pay attention to this points.
➔ Always follow these instructions

2 SCD110 BLE Settings and Connection Details

2.1 SCD110 BLE Time Intervals and Timeouts

Note: Please consider that SCD has a single timer only. Thus, the timeouts are sequential and won't run in parallel.

Name	Value	Description
BLEAdvInterval	500 ms	BLE advertisement interval. The advertisement message is sent every half a second. This is defined based on best compromise between fast connection set-up and device battery lifetime.
BLEAdvDuration	300 s	BLE advertisement duration. This is the duration of the advertisement message. SCD sends advertisement for 5 minutes. This happens when the user press the button of SCD. The advertisement message is also triggered after SCD disconnects e.g., device out of range or manual disconnect

BLEConnTimeout	120 s	BLE connection timeout. If there is no BLE activity between SCD and connected device for 2 minutes, SCD closes the connection automatically by this timeout.
minimumConnectionInterval	7.5 ms	The connection interval in BLE standard is the amount of time between two connection events
maximumConnectionInterval	12.5 ms	the connection interval in BLE standard is the amount of time between two connection events
slaveLatency	0 ms	We keep it minimum to reduce the time for SCD to receive data from central device

2.2 Maximum Transmission Unit (MTU)

Name	Value	Description
Maximum Transmission Unit (MTU) size supported by SCD	65 octets	65 bytes, working and tested with Android v8.1.0 and iOS v12.2. Incompatible with old BLE4.1 BLED112 dongles (limited to MTU size of 20B).

Note: SCD has a 65 bytes maximum transmission unit (MTU) size. It is incompatible with old BLE4.1 BLED112 dongles (limited to MTU size of 20 bytes)

2.3 Pairing Parameters

Name	Value	Description
Pairing algorithm	Just Works	This is determined by SCD's I/O capabilities: no input, no output (SCD has no keyboard, no display).
Default passkey	0	Often represented as string "000000" – imposed by Pairing algorithm 'Just Works'
Man In The Middle (MITM) protection	No	Imposed by Pairing algorithm 'Just Works'.

2.4 BLE Advertisement

SCD sends advertisement messages via BLE to allow BLE devices to establish a connection. The BLE Advertisement will be activated in following cases

- Manually activated by short button press on the device. Advertisement for 5 minutes.
- Automatically activated by disabling all sensors and streaming functions and leaving the sensor in Short Time Experiment (STE) mode. Advertisement for 5 minutes.
- After a BLE connection timeout will switch into a sleep mode. In sleep mode advertisement is activated automatically every 3 hours. Advertisement for 5 minutes.

If SCD is in DEFAULT mode, it will not enable the advertisement. Please see mode section details in: Characteristic 'Mode Selection' under 3.1.4 Service 'SCD Settings'

2.4.1 BLE Advertisement Payload

The target is to keep SCD's BLE advertising payload to a minimum. In case further information needs to be conveyed without entering in a BLE connection, the Scan procedure should be used.

Byte Position	Number of bits	Description / Meaning
0	8	Length (value = 0x02)
1	8	ID BLE_GAP_AD_TYPE_FLAGS (value = 0x01)
2	8	Advertising Mode data: • General-discoverable mode • BR/EDR Not Supported
3	8	Length (value = 0x06)
4	8	ID BLE_GAP_AD_TYPE_MANUFACTURER_SPECIFIC_DATA (value = 0xFF)
5	8	Company Identifier Code: 0x02A6 (Bosch) - low byte goes first: 0xA6 Source: https://www.bluetooth.com/specifications/assigned-numbers/company-identifiers
6	8	0x02
7	8	Bosch Sensor ID 0x5821 (SCD) low byte goes first: 0x21
8	8	0x58
9	2	(Mask 0x01) 1: SCD ready for FW transfer via Service 'Over the Air Download'. BLE connection needs to be established again before accessing that OAD service. (mask 0x02) 1: SCD's Serial Flash memory full (mask 0x04) 1: SCD has detected threshold violation Please note that the serial flash memory full flag is not persistent. During startup/init the system is not checking the remaining external flash size if there is enough space to log more sensor (depending on the config, also not stored). Thus, this flag is reset to its default value on MCU reset (mask 0x01, 0x02 and 0x04 is 0).
9	6	(Mask 0xF8) unused. 2+6bits = 1B: 0xFF - (0x01 + 0x02 + 0x04) = 0xF8
10	8	Length (value = 0x11)
11	8	ID BLE_GAP_AD_TYPE_128BIT_SERVICE_UUID_COMPLETE (value = 0x07)
12-27	128	UUID (value = 02a65821-0000-1000-2000-b05cb05cb05c) Source: Service 'SCD Settings'

2.5 SCD BLE Scan Response

SCD supports BLE Scan Procedure that can be initiated by a BLE Central device to discover static data from SCD.

2.5.1 BLE Scan Response Payload

Minimum scan response size is 15B, if the device name is set by the user to be empty. The minimum scan response bytes are aligned right hand side in table below. With (max. length 15B) device name or (15B) Serial Number the maximum scan response is 30B, aligned left hand side in table below.

Byte Position	Number of bits	Description / Meaning
0	8	Length (value = 0x05)
1	8	ID BLE_GAP_AD_TYPE_SLAVE_CONN_INTERVAL_RANGE (value = 0x12)
2	8	0x06 (low byte of 0x0006 indicating 7.5ms)
3	8	0x00 (high byte of 0x0006 indicating 7.5ms)
4	8	0x0A (low byte of 0x000A indicating 12.5ms)
5	8	0x00 (high byte of 0x000A indicating 12.5ms)
6	8	Length (value = 0x02)
7	8	ID BLE_GAP_AD_TYPE_POWER_LEVEL (value = 0x0A)
8	8	0 (indicating 0dBm)
9	8	Length - max length value: 0x05 (5B fixed) + 0x0F (variable 15B device name, default: device serial number)
10	8	ID BLE_GAP_AD_TYPE_LOCAL_NAME_COMPLETE (value = 0x09)
11	8	'S' fixed (can't be changed by user)
12	8	'C' fixed (can't be changed by user)
13	8	'D' fixed (can't be changed by user)
14	8	'-' fixed (can't be changed by user)
15-29	8	User configurable. Default value Serial Number, example: 7260919000001DA. Please note the device name is internally SNV stored without the fixed prefix "SCD-" but communicated via BLE interface with the prefix only, see Device Identifiers.

3 SCD BLE Profile

SCD's BLE profile consists of BLE Services and BLE Characteristics within a BLE Service.

3.1 SCD Universally Unique Identifiers (UUIDs)

SCD registers BLE services statically. SCD services are always discoverable even in mode selection (default mode). In default mode the services are not containing real data. After the Characteristic 'Mode Selection' is set to a specific mode, the services will be enabled to supply real data.

Specification	Service Name	Service UUID	Characteristic name	Characteristic UUID
SIG	Service 'Generic Access'	00001800-0000-1000-8000-	Characteristic 'Device Name'	00002a00-0000-1000-8000-

		00805f9b34fb		00805f9b34fb
			Characteristic 'Appearance'	00002a01-0000-1000-8000-00805f9b34fb
			Characteristic 'Peripheral Preferred Connection Parameters'	00002a04-0000-1000-8000-00805f9b34fb
SIG	Service 'Generic Attribute'	00001801-0000-1000-8000-00805f9b34fb	n/a	n/a
	Service 'Device Information'	0000180a-0000-1000-8000-00805f9b34fb	Characteristic 'System ID'	00002a23-0000-1000-8000-00805f9b34fb
			Characteristic 'Serial Number String'	00002a25-0000-1000-8000-00805f9b34fb
			Characteristic 'Firmware Revision String'	00002a26-0000-1000-8000-00805f9b34fb
			Characteristic 'Hardware Revision String'	00002a27-0000-1000-8000-00805f9b34fb
			Characteristic 'Software Revision String'	00002a28-0000-1000-8000-00805f9b34fb
			Characteristic 'Manufacturer Name String'	00002a29-0000-1000-8000-00805f9b34fb
SCD	Service 'SCD Settings'	02a65821-0000-1000-2000-b05cb05cb05c	Characteristic 'Interface Version'	02a65821-0001-1000-2000-b05cb05cb05c
			Characteristic 'Self-Test Results'	02a65821-0002-1000-2000-b05cb05cb05c
			Characteristic 'Mode Selection'	02a65821-0003-1000-2000-b05cb05cb05c
			Characteristic 'SCD generic commands'	02a65821-0004-1000-2000-b05cb05cb05c
			Characteristic 'SCD Device Name'	02a65821-0005-1000-2000-b05cb05cb05c

SCD	Service 'Short Term Experiment'	02a65821-1000-1000-2000-b05cb05cb05c	Characteristic 'STE Configuration Parameters'	02a65821-1001-1000-2000-b05cb05cb05c
			Characteristic 'STE Results'	02a65821-1002-1000-2000-b05cb05cb05c
SCD	Service 'Bulk Data Transfer'	02a65821-3000-1000-2000-b05cb05cb05c	Characteristic 'Bulk Data Transfer Control'	02a65821-3001-1000-2000-b05cb05cb05c
			Characteristic 'Bulk Data Transfer Status'	02a65821-3002-1000-2000-b05cb05cb05c
			Characteristic 'Bulk Data Transfer Data Flow'	02a65821-3003-1000-2000-b05cb05cb05c
TI	Service 'Over the Air Download'	f000ffc0-0451-4000-b000-000000000000	Characteristic 'Image Identify'	f000ffc1-0451-4000-b000-000000000000
			Characteristic 'Image Block'	f000ffc2-0451-4000-b000-000000000000
			Characteristic 'Image Count'	f000ffc3-0451-4000-b000-000000000000
			Characteristic 'Image Status'	f000ffc4-0451-4000-b000-000000000000

3.1.1 Service 'Generic Access'

SCD supports the Generic Access, a service adopted by bluetooth.org, see https://www.bluetooth.com/specifications/gatt/services/

It contains the following BLE Characteristics

- Characteristic 'Device Name'
- Characteristic 'Appearance'
- Characteristic 'Peripheral Preferred Connection Parameters'

Characteristic 'Device Name'

Byte position	Name	Format	Read Write Notify	Additional Information
0-18	Name	uint8_t[19] (utf8s)	Read only	Default device name is device Serial Number. Example: "SCD-7260919000001DA". Maximum device name length is 19 bytes, including the fixed prefix "SCD-". It is user configurable via Characteristic 'SCD Device Name'. The device name is internally stored without the fixed prefix "SCD-" but communicated via BLE always with the prefix.

Characteristic 'Appearance'

Please note that SCD doesn’t change the values in characteristic 'Appearance' but use the default values from the TI BLE stack.

Characteristic 'Peripheral Preferred Connection Parameters'

Byte position	Name	Format	Read Write Notify	Additional Information
0-1	Minimum Connection Interval	uint16_t	Read only	Default value: 7.5 ms
2-3	Maximum Connection Interval	uint16_t	Read only	Default value: 12.5 ms
4-5	Slave Latency	uint16_t	Read only	Default value: 0 ms
6-7	Connection Supervision Timeout Multiplier	uint16_t	Read only	Default value: 3000 [10ms] (= 30 s)

3.1.2 Service 'Generic Attribute'

SCD supports the Generic Attribute (TI BLE stack). It can't be configured. It doesn't contain any BLE characteristics

3.1.3 Service 'Device Information'

SCD supports the Device Information Service (DIS), a service adopted by bluetooth.org, see https://www.bluetooth.com/specifications/gatt/services/

It contains the following BLE Characteristics

- Characteristic 'System ID'
- Characteristic 'Serial Number String'
- Characteristic 'Firmware Revision String'
- Characteristic 'Hardware Revision String'

- Characteristic 'Software Revision String'
- Characteristic 'Manufacturer Name String'

Characteristic 'System ID'

See https://www.bluetooth.com/wp-content/uploads/Sitecore-Media-Library/Gatt/Xml/Characteristics/org.bluetooth.characteristic.system_id.xml

- Organizationally Unique Identifier (OUI) value assigned by the IEEE Registration Authority (IEEE RA)
  - BCDS: FCD6BD (24 bits)
- Product Code SCD: 008 (12 bits)
- Product Variant 0 (4 bits)
- example: 64-bit structure 0xFCD6BD0000000080
- Please note that this characteristic is not including the 15 bytes (120 bits) device serial number.

Byte position	Name	Format	Read Write Notify	Additional Information
0-2	Organizationally Unique Identifier (OUI)	24 bits	Read only	Default value: 0xFCD6BD
3-7	Manufacturer Identifier	40 bits	Read only	Default value for first variant of SCD: 0x0000000080

Characteristic 'Serial Number String'

It is the device serial number.

https://www.bluetooth.com/wp-content/uploads/Sitecore-Media-Library/Gatt/Xml/Characteristics/org.bluetooth.characteristic.serial_number_string.xml

Byte position	Name	Format	Read Write Notify	Additional Information
0-14	Serial number	uint8_t[15] (utf8s)	Read only	No NULL string terminator necessary. Example "7260919000001DA"

Characteristic 'Firmware Revision String'

It is the Bootloader version of the SCD. This is not the same as application software version.

Byte position	Name	Format	Read Write Notify	Additional Information
0-8	Bootloader revision	uint8_t[9] (utf8s)	Read only	Example: "v1.0.0"

Characteristic 'Hardware Revision String'

This is the Hardware version of the SCD.

Byte position	Name	Format	Read Write Notify	Additional Information
0-2	Hardware revision	uint8_t[3] (utf8s)	Read only	Example: "R01"

Characteristic 'Software Revision String'

This is the application software version in the device.

Byte position	Name	Format	Read Write Notify	Additional Information
0-8	Application software revision	uint8_t[9] (utf8s)	Read only	Example: "v1.3.0"

Characteristic 'Manufacturer Name String'

It is the name of the Manufacturer.

Byte position	Name	Format	Read Write Notify	Additional Information
0-21	Manufacturer name	uint8_t[22] (utf8s)	Read only	Default value: "bosch-connectivity.com"

3.1.4 Service 'SCD Settings'

The most important characteristic in this service is Mode Selection to select a work mode. Besides that there are some administrative information characteristics implemented in this service.

It contains following BLE Characteristics

- Characteristic 'Interface Version'
- Characteristic 'Self-Test Results'
- Characteristic 'Mode Selection'
- Characteristic 'SCD generic commands'
- Characteristic 'SCD Device Name'

Characteristic 'Interface Version'

This is the version of the SCD BLE Interface Specification. It indicates if the BLE Protocol is changed. This can be different to the embedded SW version, e.g., if the embedded SW get a bug fix patch version increment and the BLE interface stays the same, see Characteristic 'Software Revision String'.

Byte position	Name	Format	Read Write Notify	Additional Information
0	BLE specification interface version	uint8_t	Read only	Hex encoded version number to save space, example: 0x07

Characteristic 'Self-Test Results'

The value of this characteristic is a number of Booleans that are mapped to bits in an octet, each representing if a device's self-test has failed.

1 = false: self-test has failed (https://www.gnu.org/software/libc/manual/html_node/Exit-Status.html).

Byte position	Name	Format	Read Write Notify	Additional Information
0	Self-Test result	uint8_t	Read only	• mask 0x01: Flag Accelerometer self-test; 0 – success; 1 – failure (default) • mask 0x02: Flag Magnetometer self-test; 0 – success; 1 – failure (default • mask 0x04: Flag Light sensor self-test; 0 – success; 1 – failure (default) • mask 0x08: Flag Flash Memory self-test; 0 – success; 1 – failure (default) • mask 0x10: Flag Temperature Sensor self-test; 0 – success; 1 – failure (default) • mask 0x20: Flag CRC 'device specific configuration data' self-test; 0 – success; 1 – failure (default) • other masks: reserved – to be ignored

In the table below there are some examples of the self-test-results.

No	Topic	Mask	Binary
1	Accelerometer self-test failure	0xC1	11000001
2	Accelerometer self-test failure Light Sensor self-test failure	0xC5	11000101
3	Magnetometer self-test failure Flash Memory self-test failure CRC self-test failure	0xEA	11101010
4	Self-test passed successfully for all sensors – everything is ok	0xC0	11000000

Characteristic 'Mode Selection'

The value of this characteristic is a unit8 integer representing the work mode set in SCD.

Byte position	Name	Format	Read Write Notify	Additional Information
0	SCD Work Mode	unit8_t	Read and Write	0: Short term experiment (STE) 1-254: Reserved 255: Mode selection = default value Mode selection mode can only be entered after STE is stopped. After every work mode the mode selection mode needs to be entered first before going to another work mode.

Characteristic 'SCD generic commands'

The value of this characteristic is set of commands that are generic to SCD, not specific to a use case.

Byte position	Name	Format	Read Write Notify	Additional Information
0	Control command	uint 8_t	Read and write	**Default** **1. 0x00 Default value** If a control command is received the control command byte is reset to default value. Example: BLE device sends control command 0x10 to start FW download and FOTA, SCD receives command and set value back to 0x00 then SCD disconnect, advertise and after reconnect start FW download and toggle bootloader flag to enter FW update

Firmware over the Air (FOTA)

➔ **0x10 Start a firmware download**

FOTA server indicates it has a firmware image for SCD to download. The downloading process happens in following steps.

1. Release the BLE connection
2. SCD advertisement payload will indicate FOTA (see SCD BLE Advertisement 9th byte)
3. BLE connection needs to be established again before accessing the On the Air Download (OAD) service

Please note; to start FOTA the SCD must be in the “Mode Selection” mode.

Short Term Experiment (STE)

Short term experiment can only be started if mode selection is STE, see Characteristic 'Mode Selection'

➔ **0x20 Toggle STE (start/stop)**

STE is running if rolling counter is incremented, see Characteristic 'STE Results'. Please note that this could end up in a delay for evaluating if STE is running or not because this is depending on the sensor config (ODR, i.e., update rate)

The rolling counter will be incremented on each data point acquisition. It will be "1" directly after the STE start. Thus, this counter can be only be "0" when no STE is running.

➔ **0x21 cmdResetThresholdFlags (STE mode)**

Reset all threshold violation flags (all at once) indicated in Characteristic 'STE Results' and in SCD BLE Advertising. Currently available only during STE mode.

Please note that manually resetting this flags can result in a delay of accelerometer data acquisition because the accelerometer need to be reset for this (high pass filter settling time is approximately 370ms). There is no automatic reset mechanism of the accelerometer threshold flag due to this delay. Please note that there is also no automatic way to reset the flag for the other sensors. As an example, if the temperature threshold has been exceeded once, the flag won't be unset even if temperature goes below that threshold again.

Generic

➔ **0x30 cmdEraseSensorData**

This command deletes the sensor data in SCD with following steps.

1. Release the BLE connection

				2. Start the erase operation 3. Once the erase operation has completed, start BLE advertising Please note that this command deletes only the raw sensor data stored in SCD. It doesn’t delete the complete serial flash. This command deletes complete area of sensor logging data independent of the fill level. Thus, it takes some time of approximately 9 seconds.

Characteristic 'SCD Device Name'

Allows uses to assign a name to their SCD device.

Byte position	Name	Format	Read Write Notify	Additional Information
0-14	SCD Device Name	uint8_t[15]	Write only	Not NULL-terminated string. BLE only transfers the set characters, e.g., "Peter" will be "0x50 0x65 0x74 0x65 0x72". The device name is internally SNV stored without the fixed prefix "SCD-" but communicated via BLE with the prefix only, see Device Identifiers. Please note that this is write only, the device name can read by Characteristic 'Device Name'.

3.1.5 Service 'Short Term Experiment'

SCD service Short Term Experiment is not adopted by bluetooth.org, and therefore has a 128-bit UUID.

It contains the following BLE Characteristics

- Characteristic 'STE Configuration Parameters'
- Characteristic 'STE Results'

Note: <u>Please attention!</u> Before reading or writing these two characteristics, make sure that BLE server performs an MTU resize. The reason is that, standard BLE max MTU size for a characteristic is 23 bytes, but we use here for characteristic 'STE Configuration Parameters' 35 bytes and for characteristic 'STE Results' 33 bytes.

Characteristic 'STE Configuration Parameters'

The value of this characteristic is a set of parameters representing the set-up for Short Term Experiment mode.

Please note that in case of an invalid entry, SCD will set automatically the respective default value.

In case the threshold value has not been configured by the central devices, SCD will use a defined default value. Purpose of default values is to avoid the threshold violation detection from firing. To enable the threshold detection feature, the user must change the default threshold value by the desired value. It is the client's (BLE Central device) responsibility to ensure the values of this characteristic is as intended. To ensure this, it's strongly recommended the client performs a 'write–read–check'--procedure.

Byte position	Name	Format	Read Write Notify	Additional Information
0-3	UNIXtime	int32_t	Read and write	Default value: 0; data type as in POSIX standard. This parameter won't be updated from device itself like *Real Time Clock*. It needs to be set by central device (e.g. before starting an STE).
4	sensorEnDisable	uint8_t	Read and write	• mask 0x01: Flag enableAccelerometer; 0 – disabled (default); 1 – enabled • mask 0x02: Flag enableMagnetometer; 0 – disabled (default); 1 – enabled • mask 0x04: Flag enableLightSensor; 0 – disabled (default); 1 – enabled • mask 0x08: Flag enableTemperatureSensor; 0 – disabled (default); 1 – enabled • mask 0xF0: reserved – to be ignored
5	outputDataRates	uint8_t	Read and write	low nibble: accelerometerOdr • 0x?0: accelerometer ODR 400Hz (default) • 0x?1: accelerometer ODR 800Hz • 0x?2: accelerometer ODR 1600Hz • 0x?3: accelerometer ODR 3200Hz • 0x?4: accelerometer ODR 6400Hz high nibble: lightSensorOdr • 0x0?: light sensor ODR 100ms (10Hz) • 0x1?: light sensor ODR 800ms (1.25Hz) (default) All other values reserved.
6-7	accelerometer threshold	uint16_t	Read and write	Threshold for all three axis of the accelerometer. Raw value input in HEX is expected, resolution 100mg/LSB (example: 0x0A = 1g, 0x01 = 0.1g) • Threshold range 0x0028 = 40LSB = 4g to 0x07D0= 2000LSB = 200g • Threshold resolution 0x0014 = 20LSB = 2g • Threshold default value 0x07E4 = 2020LSB = 202g, disable threshold detection via max. range + resolution

				• The values being compared with the threshold are absolute values of the acceleration measurement. Therefore negative threshold values are not possible, i.e., abs(measured_acceleration) > threshold_value
8-9	reserved	-	Read and write	Reserved for future use: accelerometer threshold y-axis
10-11	reserved	-	Read and write	Reserved for future use: accelerometer threshold z-axis
12-15	light sensor threshold low	uint32_t	Read and write	Input in HEX expected. No LSB input because of the complex conversion. This is handled by the light sensor driver internally. • Threshold range 0x000003E8 = 1000mLux = 1Lux to 0x05F5E100 = 100000000mLux = 100000Lux • Threshold resolution 0x000003E8 = 1000mLux = 1Lux • Threshold default value 0x00000000 = 0mLux = 0Lux disable threshold detection
16-19	light sensor threshold high	uint32_t	Read and write	Input in HEX expected. No LSB input because of the complex conversion. This is handled by the light sensor driver internally. • Threshold range 0x000003E8 = 1000mLux = 1Lux to 0x05F5E100 = 100000000mLux = 100000Lux • Threshold resolution 0x000003E8 = 1000mLux = 1Lux • Threshold default value 0x05F5E4E8 = 100001000 mLux = 100001Lux disable threshold detection via max. range + resolution
20-21	magnetometer threshold	uint16_t	Read and write	One threshold for all three axis. Raw value input in HEX expected, resolution 1µT/16LSB • Threshold range 0x0640 = 1600LSB = 100µT to 0x5140 = 20800LSB = 1300µT • Threshold resolution 0x0640 =1600LSB = 100µT • Threshold default value 0x5780 = 22400LSB = 1400µT disable threshold detection via max. range + resolution • The values compared with the threshold are absolute value of the sensor measurement. Therefore negative threshold values are not possible.
22-23	reserved	-	Read and write	Reserved for future use: magnetometer threshold y-axis

24-25	reserved	-	Read and write	Reserved for future use: magnetometer threshold z-axis
26-27	temperature threshold low	int16_t	Read and write	Raw value input in HEX expected, resolution 0.0078125°C/LSB • Threshold range 0xF600 = -2560LSB = -20°C to 0x2A80 = 10880LSB = to +85°C • Threshold resolution 0x0280 = 640LSB = 5°C • Threshold default value 0xF380 = -3200LSB = -25°C disable threshold detection via max. range - resolution
28-29	temperature threshold high	int16_t	Read and write	Raw value input in HEX expected, resolution 0.0078125°C/LSB • Threshold range 0xF600 = -2560LSB = -20°C to 0x2A80 = 10880LSB = to +85°C • Threshold resolution 0x0280 = 640LSB = 5°C • Threshold default value 0x2D00= 11520LSB = +90°C disable threshold detection via max. range + resolution
30	sensorRawValues ToFlash	uint8_t	Read and write	• mask 0x01: Flag accelerRawValuesToFlash; 0 – disabled (default); 1 – enabled • mask 0x02: Flag magnetometerRawValuesToFlash; 0 – disabled (default); 1 – enabled • mask 0x04: Flag lightSensorRawValuesToFlash; 0 – disabled (default); 1 – enabled • mask 0x08: Flag temperatureSensorRawValuesToFlash; 0 – disabled (default); 1 – enabled • mask 0xF0: reserved – to be ignored

Example (incl. reserved 0xF0):	Mask	Binary
sensorRawValuesToFlash accelerRawValuesToFlash enabled	0xF1	11110001
sensorRawValuesToFlash accelerRawValuesToFlash enabled sensorRawValuesToFlash lightSensorRawValuesToFlash enabled	0xF5	11110101
sensorRawValuesToFlash all disabled (default)	0xF0	11110000

				Please note that this flag will be set to 0x00 when a write error to external flash is detected (after 2x write retry); more details in list below. Please also note that this flag will not be reset to default value (0xF0) after a write error (0x00) occurred it needs to be written to the default value via BLE. • STE is stopped by user --> STE is stopped (sensorRawValuesToFlash is not modified) • STE with full memory --> STE is stopped (sensorRawValuesToFlash is not modified) • STE can't be started because previous data log (this is not an error but should be indicated to the user) --> STE is stopped (sensorRawValuesToFlash is set to default: 0xF0) • STE is stopped because write error --> STE is stopped (sensorRawValuesToFlash is set to error: 0x00)
31-34	freeBytes InSerialFlash	uint32_t	Read only	Number of free bytes in serial flash device for storing raw sensor data. Until further notice, any value not equal to Maximum Value indicates serial Flash device not empty. User has to first erase serial Flash device, before Short Term Experiment can be started. Everything below 0xB0000 indicates a previous raw sensor data record. This value is updated every time the other sensor data is updated to Characteristic 'STE Results' (depending on outputDataRates). Please note that this value will only be saved (written to SNV) • at the start and • at the end of the logging during a short term experiment (0x00 < value < 0xB0000) and/or • after the flash has been erased (value = 0xB0000) and/or • on external flash write error (see above sensorRawValuesToFlash) and/or • on fatal error handling (before MCU reset). At the start of the logging during a short term experiment only the size of the logging header will be stored herein. Thus, again, everything below 0xB0000 indicates a previous raw sensor data

				record even if there is an issue in-between, another logging session during a short term experiment can't be started (no data can be overwritten). A minimum of 1024B is needed to log 1 single ADXL data. So, if the memory is less than that (e.g. 658B) then SDC will stop logging and update flash full into the advertisement payload. Free space in flash not always be zero 0x00. It depends on the enabled sensors and may vary. This is a read only field. • Min value: 0x00 • Max value: 0xB0000

Characteristic 'STE Results'

The value of this characteristic is data produced by SCD in Short Term Experiment mode

Byte position	Name	Format	Read Write Notify	Additional Information
0-1	accel ArithmMean_x	int16_t	Read and Notify	Arithmetic mean calculated on 170 samples; converting factor: 100mg/LSB
2-3	accel ArithmMean_y	int16_t	Read and Notify	Arithmetic mean calculated on 170 samples; converting factor: 100mg/LSB
4-5	accel ArithmMean_z	int16_t	Read and Notify	Arithmetic mean calculated on 170 samples; converting factor: 100mg/LSB
6-9	accel Variance_x	uint32_t	Read and Notify	Variance calculated on 170 samples; converting factor: 10-^{2}g^{2}/LSB
10-13	accel Variance_y	uint32_t	Read and Notify	Variance calculated on 170 samples; converting factor: 10-^{2}g^{2}/LSB
14-17	accel Variance_z	uint32_t	Read and Notify	Variance calculated on 170 samples; converting factor: 10-^{2}g^{2}/LSB
18-19	temperature RawValue	int16_t	Read and Notify	temperature raw value; converting factor: 0.0078°C/LSB
20-23	lightRawValue	uint32_t	Read and Notify	light raw value; converting factor: data is read in mililux

<table>
<tr><td>24-25</td><td>magnetometer Raw_x</td><td>int16_t</td><td>Read and Notify</td><td>magnetic field strength; converting factor: 16LSB/µT</td></tr>
<tr><td>26-27</td><td>magnetometer Raw_y</td><td>int16_t</td><td>Read and Notify</td><td>magnetic field strength; converting factor: 16LSB/µT</td></tr>
<tr><td>28-29</td><td>Magnetometer Raw_z</td><td>int16_t</td><td>Read and Notify</td><td>magnetic field strength; converting factor: 16LSB/µT</td></tr>
<tr><td>30-31</td><td>threshold violation</td><td>int16_t</td><td>Read and Notify</td><td>threshold violation indicated by bit set to one:
<table>
<tr><th>No</th><th>Topic</th><th>Bit-mask</th><th>Binary</th></tr>
<tr><td>1</td><td>accelerometer</td><td>0x8000</td><td>1000000000000000</td></tr>
<tr><td>2</td><td>reserved</td><td>0x4000</td><td>0100000000000000</td></tr>
<tr><td>3</td><td>reserved</td><td>0x2000</td><td>0010000000000000</td></tr>
<tr><td>4</td><td>magnetometer</td><td>0x1000</td><td>0001000000000000</td></tr>
<tr><td>5</td><td>reserved</td><td>0x0800</td><td>0000100000000000</td></tr>
<tr><td>6</td><td>reserved</td><td>0x0400</td><td>0000010000000000</td></tr>
<tr><td>7</td><td>light sensor high</td><td>0x0200</td><td>0000001000000000</td></tr>
<tr><td>8</td><td>light sensor low</td><td>0x0100</td><td>0000000100000000</td></tr>
<tr><td>9</td><td>temperature high</td><td>0x0080</td><td>0000000010000000</td></tr>
<tr><td>10</td><td>temperature low</td><td>0x0040</td><td>0000000001000000</td></tr>
</table></td></tr>
<tr><td>32</td><td>rollingCounter</td><td>uint8_t</td><td>Read and Notify</td><td>For allowing the BLE Central detect missing updates of characteristic 'STE Results'
This value can also be used to check if STE mode has a running short term experiment.
Please note that if no sensor is configured for STE live data streaming, this counter won't be increased after STE experiment is started. It is not expected that user (mobile phone app or gateway or central device) starts a STE experiment without configuring any sensor. This case is not checked or cancelled by SCD. This shall be handled by the central device.</td></tr>
</table>

3.1.6 Service 'Bulk Data Transfer' (BDT)

- Setting 'Packets per BLE Connection Interval' (<= 4) is used for speeding up transfer.
- Still quite strongly couples with transport medium BLE.
- The Bulk Data Transfer happens with notifications
- Retransmission of packets is foreseen but not yet implemented.

Note: Don't perform other BLE write and read operation while a bulk data transfer is running. This can lead to data download errors.

This service contains following BLE Characteristics

- Characteristic 'Bulk Data Transfer Control'
- Characteristic 'Bulk Data Transfer Data Flow'
- Characteristic 'Bulk Data Transfer Status'

Characteristic 'Bulk Data Transfer Control'

It controls the BLE Bulk Data Transfer (BDT).

Byte position	Name	Format	Read Write Notify	Additional Information
0	BDT control	uint8_t	Write	0: Go to idle • If transfer ongoing: SCD terminates the ongoing BDT • If transfer finished: SCD goes to idle state • If error: SCD goes to idle state 1: Start transfer of Sensor Data. • If idle : SCD starts transfer • If transfer is ongoing: No effect, SCD continues transfer • If error: SCD does nothing

Characteristic 'Bulk Data Transfer Data Flow'

Data flow of BDT.

Byte position	Name	Format	Read Write Notify	Additional Information
0-19	BDT data flow	uint8_t[20]	Read and notify	See following descriptions for details

Packet Structure

A data flow package will always be 20 bytes long. The first 4 Bytes (B_0 .. B3) are used to indicate the 32-Bit current package number.

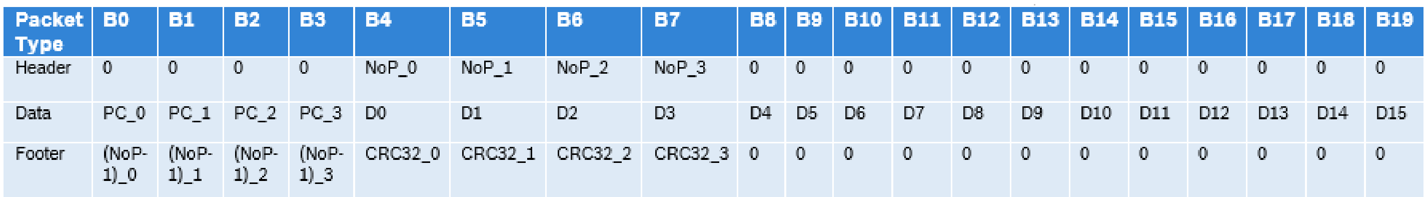
- Package 0 is the header package.
- Packages 1 to NoP-2 are used for memory payload and
- Package NoP-1 is the footer package

32-Bit numbers are sent in ascending byte order (LSB first).

Data payload is sent in ascending byte order as stored in memory.

Bits not used are considered as reserved and should be zero-padded.

Packet Outline



Packet Type	B0	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15	B16	B17	B18	B19
Header	0	0	0	0	NoP_0	NoP_1	NoP_2	NoP_3	0	0	0	0	0	0	0	0	0	0	0	0
Data	PC_0	PC_1	PC_2	PC_3	D0	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15
Footer	(NoP-1)_0	(NoP-1)_1	(NoP-1)_2	(NoP-1)_3	CRC32_0	CRC32_1	CRC32_2	CRC32_3	0	0	0	0	0	0	0	0	0	0	0	0

Offset

Start address of raw sensor data partition in flash memory

This value is not transmitted

Partition Size

Before sending, the partition size is checked if it is a multiple of 16-Bytes. If not it is incremented to the next multiple of 16

Number of Packets (NoP)

The Number-Of-Packets is a 32-Bit value stored in bytes 0-4, also denoted as NoP_0, NoP_1, NoP_2, NoP_3. First byte transmitted (NoP_0) is LSB

The number of packets is related to the number of data bytes (partition size) to be sent plus the header and footer packages. NoP = partitionSize / 16 + 2.

Packet Counter (PC)

The packet stored counter is a 32-Bit value in bytes 0-4 also denoted as PC_0, PC_1, PC_2, PC_3. First byte transmitted (PC_0) is LSB

A packet counter of 0 indicates a header packet.

A packet counter of values from 1 to (NoP - 2) indicates a data packet.

A packet counter of value NoP-1 indicates a footer packet.

The packet counter is incremented with each read, notification or indication.

Once the value NoP-1 has been reached, each subsequent read will continue to show the value NoP -1

Data

The data bytes is a 16-Byte array stored in bytes 4-19 → D0 ...D15. First byte transmitted has the lowest address in memory

In the last data package (NoP 2) the unused data bytes are to be padded with 0xFF (all bits are one padded)

CRC32

The CRC32 value is a 32-Bit value stored in bytes 4-7, also denoted as CRC32_0, CRC32_1, CRC32_2, CRC32_3. First byte transmitted (CRC32_0) is LSB

The CRC32 value is calculated only using the data bytes and is only transmitted in the footer packet.

Characteristic 'Bulk Data Transfer Status'

Reflects the status of SCD's Bulk Data Transfer

Byte position	Name	Format	Read Write Notify	Additional Information
0	BDT status	uint8_t	Read only	• 0: Idle → No data is sent • 1: Transfer ongoing → Data is sent from SCD to central device using notifications • 2: Transfer finished → Transfer has been finished • 3: BDT Error → No data is sent. SCD is in an error state

3.1.7 Service 'Over the Air Download' (OAD)

This service contains following BLE Characteristics

- Characteristic 'Image Block'
- Characteristic 'Image Count'
- Characteristic 'Image Identify'
- Characteristic 'Image Status'

Please see this TI document for further details about “Over the Air Download”: http://dev.ti.com/tirex/content/simplelink_cc13x0_sdk_1_30_00_06/docs/blestack/html/cc1350/oad/oad.html

Characteristic 'Image Block'

SCD implements the TI specification for Image Block without any modification. Please see the details here:
http://dev.ti.com/tirex/content/simplelink_cc13x0_sdk_1_30_00_06/docs/blestack/html/cc1350/oad/oad.html#oad-image-block-characteristic-0xffc2

Characteristic 'Image Count'

The OAD Image Count characteristic is used to set the number of OAD images to be downloaded. SCD implements the TI specification for Image Count without any modification. Please see the details here:
http://dev.ti.com/tirex/content/simplelink_cc13x0_sdk_1_30_00_06/docs/blestack/html/cc1350/oad/oad.html#oad-image-count-characteristic-0xffc3

Characteristic 'Image Identify'

SCD implements the TI specification for Image Identify without any modification. Please see the details here:
http://dev.ti.com/tirex/content/simplelink_cc13x0_sdk_1_30_00_06/docs/blestack/html/cc1350/oad/oad.html#oad-image-identify-0xffc1

Characteristic 'Image Status'

SCD implements the TI specification for Image Status without any modification. Please see the details here:
http://dev.ti.com/tirex/content/simplelink_cc13x0_sdk_1_30_00_06/docs/blestack/html/cc1350/oad/oad.html#oad-image-status-0xffc4

For further assistance, please send an e-mail to: support@bosch-connectivity.com

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