Sensor Maestros

SFM2 BLE Characteristics Map

1.0 Summary

The SFM2 has a total of 19 characteristics, 16 of them support notifications.

Name	ID	Read	Notify	Write
Data_Stream	0x0101		X	
Data_Stream_Settings	0x0102	X	X	X
Sensor_Fusion_Settings	0x0122	X	X	X
Reference_settings	0x0128	X	X	X
Tare	0x0129			X
Time	0x0131	X	X	X
Time_Offset	0x0132	X	X	
Name	0x0133	X	X	X
Settings_Storage	0x0134			X
Calibration_Storage	0x0135			X
Stats	0x0137	X	X	X
Connection_Parameters	0x0138	X	X	
Time_Trim	0x0142	X	X	X
Time_Notify_Interval	0x0143	X	X	X
Accelerometer_Settings	0x0201	X	X	X
Gyroscope_Settings	0x0202	X	X	X
Magnetometer_Settings	0x0203	X	X	X
SF_Kalman_Settings	0x0204	X	X	X
Calibration	0x0206	X	X	
Calibration Settings	0x0207	X	X	X
Self-Test	0x0208	X	X	X
Env._Sensors_Settings	0x0310	X	X	X
Altitude Tare	0x0311			X

2.0   Data Stream Characteristics

The Data Stream characteristic is used to send sensor data from the SFM2. The transmission is started by enabling BLE notifications of the *Data Stream characteristic* (writing its CCCD). The type of sensor data to be sent can be chosen by enabling the various sensor data types via the Data Stream Settings characteristic as shown further below.

2.1   Data Stream 0x0101

The data stream characteristic sends data in the binary frame format (see SFM2 - Binary frame document). The characteristic supports notifications only, each notification contains a chunk of data. The data chunks are not aligned in any way, they should be treated as if received from a serial port. The client is responsible for stitching the chunks together and dividing it into frames.

2.2   Data Stream Settings 0x0102

Data Stream Settings allow for individualized control of what sensor data is included in the Data Stream itself. It also allows for individualized control of the USB output to be Binary or ASCII.

Size		Name	Description
15 bytes	1 byte	binmode	Enables binary data mode on USB interface. 1-enabled, 0-disabled
	1 byte	ade	Enables accelerometer (AD) data. 1-enabled, 0-disabled
	1 byte	gde	Enables gyroscope (GD) data. 1-enabled, 0-disabled
	1 byte	mde	Enables magnetometer (MD) data. 1-enabled, 0-disabled
	1 byte	sfqde	Enables untared quaternion (SFQ) data. 1-enabled, 0-disabled
	1 byte	sfqtde	Enables tared quaternion (SFQT) data. 1-enabled, 0-disabled
	1 byte	sflade	Enables linear acceleration (SFLA) data. 1-enabled, 0-disabled
	1 byte	sfeade	Enables Euler angles (SFLA) data. 1-enabled, 0-disabled
	1 byte	sfchtde	Enables Heading-Tilt (SFCHT) data. 1-enabled, 0-disabled
	1 byte	sfmde	Enables calibrated magnetometer (SFM) data. 1-enabled, 0-disabled
	1 byte	pde	Enables pressure (PD) data. 1-enabled, 0-disabled
	1 byte	altde	Enables altitude (ALT) data. 1-enabled, 0-disabled

1 byte	tde	Enables temperature (TD) data. 1-enabled, 0-disabled
1 byte	hde	Enables humidity (HD) data. 1-enabled, 0-disabled
1 byte	tsde	Enables time sync (TS) data. 1-enabled, 0-disabled

3.0   Settings characteristics

Settings characteristics are used to configure the device. They support reading, writing and emit notifications.

3.1   Sensor Fusion settings 0x0122

Sensor Fusion Settings provide control over the Fusion Output Data Rate(ODR) and also over the Output Divider setting which allows the Fusion ODR to run at a higher rate than the actual Data Rate that is sent to the BLE and USB interfaces. EXAMPLE – User can run the Fusion Library at 833Hz with the Output Divider set to 2 and the data rate sent to the BLE & USB interfaces is only 833Hz/2. This effectively provides a means to oversample the Sensor Fusion Data.

Size	Name	Description
1 byte	rate	**Data_rate**
1 byte	Output Divider	Divides Fusion ODR Data Rate to BLE or USB interface

3.2   Data rate

Data rate is a single byte setting that is used to configure data rate.

Value	Rate
0x00	0 Hz
0x01	12.5 Hz
0x02	26 Hz
0x03	52 Hz
0x04	104 Hz
0x05	208 Hz
0x06	417 Hz
0x07	833 Hz
0x08	1667 Hz

3.3   Fusion ODR Output Divider

The Fusion ODR Output Divider can be set to scale the actual Fusion ODR that is sent across the BLE or USB interface. This effectively provides a means to run the Fusion Library in an 'Oversampling' mode while allowing a slower data rate to the BLE or USB interface.

Example – Configure the Fusion Data Rate to 833Hz(0x07)
Fusion ODR Output Divider = 2, yields 833Hz/2 data rate for the BLE or USB data stream. Fusion ODR Output Divider = 4, yields 833Hz/4 data rate for the BLE or USB data stream.

Size	Name	Description
1 byte	Fusion ODR Output Divider	Integer value between 1 and 255

4.0   Reference Settings 0x0128

Size		Name	Description
17 bytes	4 bytes	w	The real component of tare quaternion, Float32
	4 bytes	x	The i vector component of tare quaternion, Float32
	4 bytes	y	The j vector component of tare quaternion, Float32
	4 bytes	z	The k vector component of tare quaternion, Float32
	1 byte	globref	Global reference frame. 1-enabled, 0-disabled

5.0   Accelerometer Settings 0x0201

Size		Name	Description
7 bytes	1 byte	rate	**Data_Rate**
	1 byte	full scale	**Full_Scale**
	1 byte	lpf2	LPF2 second stage selected, 1-enabled, 0-disabled
	1 bytes	filter	**Filter_Configuration**
	1 byte	fast_settling	Filter fast settling. 1-enabled, 0-disabled
	1 byte	power_mode	**Power_Mode**
	1 byte	self_test	**Self-Test Disturbance Configuration**

5.1   Accelerometer Full Scale
Used to configure full scale of accelerometer

Value	Rate
0x00	2 G
0x01	4 G
0x02	8 G
0x03	16 G

5.2   Accelerometer Filter Configuration

Value	Filter
0x00	HP_PATH_DISABLE_ON_OUT

0x10	SLOPE_ODR_DIV_4
0x11	HP_ODR_DIV_10
0x12	HP_ODR_DIV_20
0x13	HP_ODR_DIV_45
0x14	HP_ODR_DIV_100
0x15	HP_ODR_DIV_200
0x16	HP_ODR_DIV_400
0x17	HP_ODR_DIV_800
0x31	HP_REF_MD_ODR_DIV_10
0x32	HP_REF_MD_ODR_DIV_20
0x33	HP_REF_MD_ODR_DIV_45
0x34	HP_REF_MD_ODR_DIV_100
0x35	HP_REF_MD_ODR_DIV_200
0x36	HP_REF_MD_ODR_DIV_400
0x37	HP_REF_MD_ODR_DIV_800
0x01	LP_ODR_DIV_10
0x02	LP_ODR_DIV_20
0x03	LP_ODR_DIV_45
0x04	LP_ODR_DIV_100
0x05	LP_ODR_DIV_200
0x06	LP_ODR_DIV_400
0x07	LP_ODR_DIV_800

5.3 Accelerometer Power Mode

Value	Rate
0x00	High performance
0x01	Normal
0x02	Ultra low power

5.4 Self-Test Configuration

Self-test disturbance configuration. Used for both accelerometer and gyro.

Value	Rate

0x00	Off
0x01	Positive
0x02	Negative

6.0   Gyroscope Settings 0x0202

Size		Name	Description
6 bytes	1 byte	rate	**Data_rate**
	1 byte	full scale	**Gyro_Full Scale**
	1 byte	lpf1	**LPF1 Configuration**
	1 bytes	high_perf	High performance mode. 1-enabled, 0-disabled
	1 byte	hpf	**High Pass Filter Configuration**
	1 byte	self_test	**Self-test Disturbance Configuration**

6.1   Gyroscope Full Scale
Used to configure full scale of gyroscope

Value	Rate
0x00	125 °/s
0x01	250 °/s
0x02	500 °/s
0x03	1000 °/s
0x04	2000 °/s

6.2   Gyroscope LPF1 Configuration

Value	Rate
0x00	Ultra light

0x01	Very light
0x02	Light
0x03	Medium
0x04	Strong
0x05	Very strong
0x06	Aggressive
0x07	Extreme
0x08	Off

6.3   Gyroscope HPF Configuration

Value	Rate
0x00	None
0x80	16 mHz
0x81	65 mHz
0x82	260 mHz
0x83	1.04 Hz

7.0   Magnetometer Settings 0x0203

Size		Name	Description
5 bytes	1 byte	rate	**Data_rate**
	1 byte	temp_comp	Temperature compensation. 1-enabled, 0-disabled
	1 byte	low_power	Low power mode. 1-enabled, 0-disabled
	1 byte	low_pass_filter	Low pass filter. 1-enabled, 0-disabled
	1 byte	self-test	Self-test disturbance enabled. 1-enabled, 0-disabled

8.0   SF Kalman Settings 0x0204

Size		Name	Description
20 bytes	4 bytes	qvy	Gyro sensor noise variance units (deg/s)^2

4 bytes	qvg	Accelerometer sensor noise variance units g^2 defining minimum deviation from 1g sphere.	
4 bytes	qvb	Magnetometer sensor noise variance units uT^2 defining minimum deviation from geomagnetic sphere.	
4 bytes	qwb	Gyro offset random walk units (deg/s)^2	
4 bytes	max_bpl	Maximum absolute permissible power on gyro offsets(deg/s)	

9.0   Calibration Settings 0x0207

Size	Name		Description
20 bytes	1 byte	mode	**Magnetometer Calibration Auto Storage Mode**
	1 byte	threshold	**Magnetometer Calibration Type**

10.0 Magnetometer Calibration Auto Storage Mode

Value	Mode	Comment
0x00	Off	Auto storage disabled
0x01	Once	Magnetometer calibration will be stored once.
0x02	Always	Magnetometer calibration will be stored each time new calibration is calculated.

11.0 Magnetometer Calibration Type

Value	Threshold
0x00	None
0x01	4 element
0x02	7 element
0x03	10 element

12.0 Environmental Sensors Settings 0x0310

These settings provide configuration for the Pressure(LPS22H) and Temperature/Humidity(ENS210) sensors on the SFM2.

Size	Name	Description
	4 bytes	zero_pressure	Pressure at 0 m. Used to tare altitude, in hPa. Float32.

17 bytes	4 bytes	alarm_up	High altitude alarm threshold, in m. Set to NAN to disable. Float32.
	4 bytes	alarm_down	Low altitude alarm threshold, in m. Set to NAN to disable. Float32.
	1 byte	Pressure_Data_Rate	**Pressure Data Rate**
	1 byte	lps22hh_low_noise	LPS22HH low noise mode. 1-enabled, 0-disabled.
	1 byte	T/H_sampling_mode	**T/H Sampling Mode**
	2 bytes	ens210_interval	ENS210 sampling interval. Used only when sensor is in *Interval* sampling mode. In ms. Uint16

12.1 Pressure Data Rate

LPS22HH Pressure Sensor Data Rate

Value	Rate
0x00	0 Hz
0x01	1 Hz
0x02	10 Hz
0x03	25 Hz
0x04	50 Hz
0x05	75 Hz
0x06	100 Hz

12.2 T/H Sampling Mode

ENS210 Combo Temperature and Humidity Sensor Sampling Mode

Value	Mode	Comment
0x00	Off	Sensor disabled
0x01	Interval	Sampling at configured interval
0x02	Continuous	Sampling as fast as possible

13.0 Storage Characteristics

Storage characteristic control storing data in non-volatile memory.

13.1 Settings Storage 0x0134

Settings storage is a write-only characteristic. It can be written with single byte commands. Each command triggers an action, depending on the value written.

Value	Action

0x01	Store settings in non-volatile memory
0x02	Restore settings from non-volatile memory
0x03	Restore settings to factory defaults. This does not overwrite non-volatile memory.

13.2 Calibration Storage 0x0135

Calibration storage is a write-only characteristic. It can be written with single byte commands. Each command triggers an action, depending on the value written.

Value	Action
0x01	Store magnetometer calibration in non-volatile memory
0x02	Clear magnetometer calibration storage.

14.0 Time characteristics

Time characteristics are used to control the accurate RTC clock running on the SFM2.

14.1 Time 0x0131

The time characteristic allows the user to read or set the RTC Clock running on the SFM2. The time is given in RTC ticks. The RTC tick frequency is 32,768Hz.

Size	Name	Description
4 bytes	time	RTC time in ticks. UInt32

14.2 Time offset 0x0132

Time offset characteristic can be used to apply an offset to the RTC time. Each write to the offset characteristic shift the time by the same amount.

Size	Name	Description
4 bytes	offset	Time offset in ticks. Int32

14.3 Time trim 0x0142

Time trim characteristic can be used to (effectively) trim the frequency of the RTC clock. The actual tick frequency can't be changed. Instead, the trim works by either adding or subtracting one additional tick at a given interval. If the trim value is positive then a tick is added at the interval, if it's negative then a tick is subtracted. When the value is 0 there are no additional ticks.

Size	Name	Description
4 bytes	trim	RTC time trim in ticks. Int32

14.4 Time Notify Interval 0x0143

Time notify interval characteristic configures the interval at which the *Time characteristic* sends notifications. The notifications are disabled if the interval is set to 0.

Size	Name	Description
4 bytes	interval	Notify interval. In 1/1024 second steps. Int32

15.0 Other characteristics

15.1 Tare 0x0129

Tare characteristic can be used to tare the sensor fusion in current orientation. It is write-only.

Size	Name	Description
1 bytes	tare	Tare command. 1 - full tare, 2 - heading tare

15.2 Name 0x0133

Name characteristic can be used to read or configure the device's name. The name gets updated immediately after write. The name will be what the unit shows in the BLE Advertisement.

The name is ASCII encoded, without the null terminator. The characteristic is of variable length, with a maximum length of 16.

15.3 Stats 0x0137

Once every 2 seconds the device's statistics are transmitted through the stats characteristic. It can also be read directly to immediately get the statistics. Writing any value to this characteristics clears the stats.

Size		Name	Description
24 bytes	4 bytes	runtime	Device runtime in ticks (1/1024 s). UInt32
	4 bytes	ble_sent	Count of bytes sent through BLE. UInt32.
	4 bytes	ble_dropped	Count of bytes dropped when sending via BLE. UInt32.
	4 bytes	serial_sent	Count of bytes written to serial. UInt32

	4 bytes	serial_dropped	Count of bytes dropped when writing to serial. UInt32
	2 bytes	max_queue	Maximum count of element in IMU queue.
	2 bytes	calibration_stores	The number of times the magnetometer calibration was stored.

15.4 Connection Parameters 0x0138

The connection parameters characteristic holds the current BLE connection parameters. It is updated each time any of the parameters changes.

Size		Name	Description
24 bytes	2 bytes	mtu	MTU, in bytes. UInt16.
	2 bytes	connection_interval	Connection Interval in 1.25 ms units. 0 if not set. UInt16.
	2 bytes	slave_latency	Slave Latency in number of connection events. -1 if not set. Int16.
	2 bytes	conn_sup_timeout	Connection Supervision Timeout in 10 ms units. 0 if not set. UInt16.
	1 byte	tx_phy	TX **PHY**
	1 byte	rx_phy	RX **PHY**

15.5 PHY

Value	Phase
0x00	Not set (unknown).
0x01	1M
0x02	2M
0x04	Coded

15.6 Calibration 0x0206

Calibration characteristic provides the magnetometer current calibration status.

Size		Name	Description
20 bytes	4 bytes	Error	Calibration error in %. Float32
	1 byte	Type	**Calibration Type**

15.7 Self-test 0x0208

Self-test characteristic can be used to trigger and monitor self-test. The characteristic can be read and emits notifications. Writing any value to it starts self-test.

Size	Name	Description

4 bytes	1 byte	phase	**Self-test Phase**
	1 byte	accel	Accelerometer result. (1 - ok, 0 - failure)
	1 byte	gyro	Gyroscope result. (1 - ok, 0 - failure)
	1 byte	mag	Magnetometer result. (1 - ok, 0 - failure)

15.8 Self-test phase

Value	Phase
0x00	Never run
0x01	Base measurement
0x02	Positive disturbance measurement
0x03	Negative disturbance measurement
0x04	Completed

15.9 Altitude Tare 0x0311

Writing any value to the *Altitude tare characteristic* tares the altitude (sets it to 0). The altitude/pressure sensor must be enabled for the tare to work.

Size	Name	Description
1 byte	tare	Altitude tare command. Write a 1 to Tare the Altitude data output