RW BLE Continuous Glucose Monitoring Profile Interface Specification

Interface Specification

RW-BLE-CGMP-IS

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1 Overview

1.1 Document Overview

This document describes the non-standard interface of the RivieraWaves (RW) Bluetooth Low Energy (BLE) Continuous Glucose Monitoring Profile (CGMP) implementation. Along this document, the interface messages will be referred to as API messages for the profile block(s).

Their description will include their utility and reason for implementation for a better understanding of the user and the developer that may one day need to interface them from a higher application.

1.2 Protocol Overview

The BLE CGMP enables a CGM Collector device to obtain glucose measurement and other data from a CGM Sensor that exposes the CGM Service. Within this profile, two roles can be supported: Sensor role (CGMS) and Collector role (CGMC). The Collector role must support the GAP Central role and the Sensor role, the GAP Peripheral role. The profile requires a connection to be established between the two devices for its functionality.

The various documents edited by the Bluetooth SIG present different use cases for this profile, their GATT, GAP and security, mandatory and optional requirements. The CGMP/CGMS specifications have been adopted by the Bluetooth SIG on December 15th 2015 ([1] and [2]). Their related Test Specifications have been released and are referenced in [3] and [4].

The profile is implemented in the RW-BLE software stack as two tasks, one for each role. Each task has an API decided after the study of the profile specifications and test specifications, and it is considered to be minimalistic and designed for a future application which would combine the profile functionality with the device connectivity and security procedures.

1.3 Services of the Continuous Glucose Monitoring Profile

CGMP includes a number of mandatory and optional services listed below:

- **Continuous Glucose Monitoring Service - mandatory**
- **Device Information Service – mandatory**
- Bond Management Service – optional, required if multiple bonds are supported by server

The remainder of this document focuses on the support of the CGM Service in the Collector and the Sensor. For details of the DIS support, please read [5].

Note: Bond Management Service is not yet supported in the IP stack.

1.4 Continuous Glucose Monitoring Service Characteristics

The characteristic requirements of the CGM Service are shown in Table 1 below. Unless otherwise specified, only one instance of each characteristic is permitted within each service.

Characteristic Name	Requirements	Properties	Security	Descriptors
CGM Measurement	Mandatory	Notify	Authentication required	Client Characteristic Configuration • Requirements: Mandatory • Properties: Write (Read *)
CGM Feature	Mandatory	Read	Authentication required	None
CGM Status	Mandatory	Read	Authentication required	None
CGM Session Start Time	Mandatory	Read, Write	Authentication required	None
CGM Session Run Time	Mandatory	Read	Authentication required	None
Record Access Control Point	Mandatory	Indicate, Write	Authentication required	Client Characteristic Configuration • Requirements: Mandatory • Properties: Write (Read *)
CGM Specific Ops Control Point	Mandatory	Indicate, Write	Authentication required	Client Characteristic Configuration • Requirements: Mandatory • Properties: Write (Read *)

Table 1 – Characteristics of Body Composition Service

Note: (Read *): Readable with no authentication or authorization already defined.

2 API Messages

2.1 Server API

2.1.1 Initialization

During the initialization phase of the CGM Server, the memory for this task must be allocated using the message GAPM_PROFILE_TASK_ADD_CMD (see [6]) provided by the GAPM interface. Application should provide the following parameter.

Type	Parameters	Description
uint32_t	feature	CGM supported features. (see Table 2)

Description: This API message shall be used to add one instance of the CGM Service in the database.

The feature parameter shall be used to determine the supported features of the Server. Values of this parameter are set using the following masks:

Bit	Name	Description
0	CGM_FEAT_CALIB_SUP	Indicate if Calibration feature is supported
1	CGM_FEAT_PAT_HIGH_LOW_ALERT_SUP	Indicate if Patient High/Low Alerts feature is supported
2	CGM_FEAT_HYPO_ALERT_SUP	Indicate if Hypo Alert feature is supported
3	CGM_FEAT_HYPER_ALERT_SUP	Indicate if Hyper Alert feature is supported
4	CGM_FEAT_RATE_OF_INCR_DECR_ALERT_SUP	Indicate if Rate of Increase/Decrease Alert feature is supported
5	CGM_FEAT_DEV_SPEC_ALERT_SUP	Indicate if Device Specific Alert feature is supported
6	CGM_FEAT_SENSOR_MALFUNC_DETEC_SUP	Indicate if Sensor Malfunction Detection feature is supported
7	CGM_FEAT_SENSOR_TEMP_HIGH_LOW_DETECT_SUP	Indicate if Temperature High-Low Detection feature is supported
8	CGM_FEAT_SENSOR_RESULT_HIGH_LOW_DETECT_SUP	Indicate if Result High-Low Detection feature is supported
9	CGM_FEAT_LOW_BATT_DETECT_SUP	Indicate if Low Battery Detection feature is supported
10	CGM_FEAT_SENSOR_TYPE_ERR_DETECT_SUP	Indicate if Sensor Type Error Detection feature is supported
11	CGM_FEAT_GENERAL_DEV_FAULT_SUP	Indicate if General Device Fault feature is supported
12	CGM_FEAT_E2E_CRC_SUP	Indicate if E2E-CRC feature is supported
13	CGM_FEAT_MULTI_BOND_SUP	Indicate if Multiple Bond feature is supported
14	CGM_FEAT_MULTI_SESS_SUP	Indicate if Multiple Sessions feature is supported
15	CGM_FEAT_CGM_TREND_INFO_SUP	Indicate if CGM Trend Information feature is supported
16	CGM_FEAT_QUALITY_SUP	Indicate if CGM Quality feature is supported

Table 2 – CGM Feature Characteristic bit field

Note: The corresponding bits of supported feature shall be set to 1 and bits of unsupported feature shall be set to 0.

2.1.2 CGMS_ENABLE_REQ

Source: TASK_APP

Destination: TASK_CGMS

Parameters:

Type	Parameters	Description
uint8_t	prfl_ntf_ind_cfg	Profile characteristic configuration for the current connection: - Bit 0 CGM Measurement characteristic notification configuration - Bit 1 Record Control Access Point indication (RACP) configuration - Bit 2 CGM Specific Ops Control Point indication configuration

Response: CGMS_ENABLE_RSP (see 2.1.3)

Description: This message is used after the connection with a peer device in order to restore known device bond data.

2.1.3 CGMS_ENABLE_RSP

Source: TASK_CGMS

Destination: TASK_APP

Parameters:

Type	Parameters	Description
uint8_t	status	Indicates success/failure of the previous CGMS_ENABLE_REQ (see [7])

Response: None

Description: Indicates the outcome of the previous CGMS_ENABLE_REQ (see 2.1.2)

2.1.4 CGMS_MEAS_VALUE_CMD

Source: TASK_APP

Destination: TASK_CGMS

Parameters:

Type	Parameters	Description
uint8_t	operation	Operation code for complete event (see Table 10)
uint8_t	flags	Selects the valid contents of the message – if field is not selected in the flags field - it will not be transmitted to the collector. (see Table 11)
prf_sfloat	gluc_concent	CGM Glucose Concentration in mg/dL as a SFLOAT data type (see Table 12)
uint16_t	time_offset	The relative time difference of the single CGM values to the session start time in minutes
uint8_t	warn	Warning octet of Sensor Status Annunciation (see Table 13)
uint8_t	cal_temp	Calibration and temperature octet of Sensor Status Annunciation(see Table 13)
uint8_t	status	Status octet of Sensor Status Annunciation (see Table 13)
prf_sfloat	trend_info	CGM Trend Information in (mg/dL)/min as a SFLOAT data type (see Table 12)
prf_sfloat	quality	CGM Quality in percentage as a SFLOAT data type (see Table 12)

Response: CGMS_CMP_EVT (see 2.1.13)

Description: This message is used by the application to provide an updated glucose measurement to the collector/client. If the CCC (NTF MEAS bit 0 of current connection) has been enabled for notification to the peer then the contents of the message (selected by the flags field) will be sent to the peer. If the message is sent by the application when the CCC is not configured for notification, then an error will be returned in the CGMS_CMP_EVT.

The contents of the message transmitted are dependent on the flags field that selects which fields of the message should be transmitted to the peer. However, if the flags field indicates an unsupported feature (according to the value of CGM Feature Characteristic), the corresponding field will not be transmitted and the flags field will be adjusted.

2.1.5 CGMS_WR_SESS_START_TIME_IND

Source: TASK_CGMS

Destination: TASK_APP

Parameters:

Type	Parameters	Description
struct prf_date_time	sess_st_time	Session Start Time value (see Table 3)
int8_t	time_zone	Offset from UTC in number of 15 minutes increments (-48..+56)
uint8_t	dst_offset	Daylight Saving Time Offset - CGM_DST_OFFSET_STANDARD_TIME = 0 - CGM_DST_OFFSET_HALF_AN_HOUR_DAYLIGHT_TIME = 2 - CGM_DST_OFFSET_DAYLIGHT_TIME - CGM_DST_OFFSET_DOUBLE_DAYLIGHT_TIME =8 - CGM_DST_OFFSET_UNKNOWN_DAYLIGHT_TIME = 255

Response: None

Description: This message is used to inform the application about the time of the initial CGM measurement received from the Collector by CGMC_WRITE_SESS_START_TIME_CMD (see 2.2.5).

2.1.6 CGMS_RD_CHAR_REQ_IND

Source: TASK_CGMS

Destination: TASK_APP

Parameters:

Type	Parameters	Description
uint8_t	char_type	Characteristic type ID: - CGMS_CHAR_ID_MEAS_CCC = 1 - CGMS_CHAR_ID_OPS_CTRL_PT_CCC = 2 - CGMS_CHAR_ID_RACP_CCC = 3 - CGMS_CHAR_ID_STATUS_VAL = 4 - CGMS_CHAR_ID_SESSION_START_TIME_VAL = 5 - CGMS_CHAR_ID_SESSION_RUN_TIME_VAL = 6

Response: None

Description: This message is used to inform the application about the characteristic for which the Collector has been searching by CGMC_READ_CMD (see 2.2.3).

2.1.7 CGMS_RD_CHAR_CFM

Source: TASK_APP

Destination: TASK_CGMS

Parameters:

Type	Parameters	Description
uint8_t	char_type	Characteristic type ID: - CGMS_CHAR_ID_MEAS_CCC = 1 - CGMS_CHAR_ID_OPS_CTRL_PT_CCC = 2 - CGMS_CHAR_ID_RACP_CCC = 3 - CGMS_CHAR_ID_STATUS_VAL = 4 - CGMS_CHAR_ID_SESSION_START_TIME_VAL = 5 - CGMS_CHAR_ID_SESSION_RUN_TIME_VAL = 6
uint8_t	status	Operation status (see [7])
union	value	Data for the read characteristic: - struct cgms_rd_status status (see Table 14) - struct cgms_rd_sess_start_time sess_start_time (see Table 15) - stuct cgms_rd_sess_run_time sess_run_time (see Table 16)

Response: None

Description: This message shall be sent by application after receiving a CGMS_RD_CHAR_REQ_IND (see 2.1.6).

2.1.8 CGMS_WR_CHAR_CCC_IND

Source: TASK_CGMS

Destination: TASK_APP

Parameters:

Type	Parameters	Description
uint8_t	char_type	Characteristic CCC type ID: - CGMS_CHAR_ID_MEAS_CCC = 1, CCC for Measurement - CGMS_CHAR_ID_OPS_CTRL_PT_CCC = 2, CCC for Specific Ops control Point - CGMS_CHAR_ID_RACP_CCC = 3, CCC for RACP
uint16_t	ind_cfg	Client Characteristic Configuration value (see Table 4)

Response: None

Description: This message is used to inform the application that the specific CCC has been changed. The new CCC as well as its characteristic type will be sent.

2.1.9 CGMS_WR_RACP_IND

Source: TASK_CGMS

Destination: TASK_APP

Parameters:

Type	Parameters	Description
uint8_t	cp_opcode	Control Point Opcodes (see Table 24)
uint8_t	cp_operator	Control Point Operators (see Table 25)
uint8_t	filter_type	Filter type: - CGMP_FILTER_TIME_OFFSET = 1
uint16_t	min_time_offset	minimum filter value

uint16_t	max_time_offset	maximum filter value

Response: None

Description: This message is used to inform the application about the new Control Point command.

2.1.10 CGMS_RACP_RESP_CMD

Source: TASK_APP

Destination: TASK_CGMS

Parameters:

Type	Parameters	Description
uint8_t	operaion	Operation code for Complete Event command: - CGMS_RACP_CMD_OP_CODE = 3
uint8_t	cp_opcode	Record Access Control Point Opcodes (see Table 24)
uint8_t	cp_operator	Control Point Operator (see Table 25)
uint8_t	req_cp_code	Request Control Point Opcodes (see Table 24)
uint8_t	rsp_code	Record Access Control Point Response code (see Table 26)
uint16_t	records_num	Number of records

Response: None

Description: This message is used to send RACP indication CGMC_VALUE_IND (see 2.2.9) to Client.

2.1.11 CGMS_WR_OPS_CTRL_PT_REQ_IND

Source: TASK_CGMS

Destination: TASK_APP

Parameters:

Type	Parameters	Description
uint8_t	opcode	CGM Control Point Opcode (see Table 17)
uint8_t	rsp	CGM Specific Ops Control Point response code (see Table 27)
union cgmp_ops_ operand	operand	CGM Control Point operand related to CGM Control Point Opcode (see Table 18)

Response: None

Description: This message is used to inform the application about the new Ops Control Point command CGMC_WRITE_OPS_CTRL_PT_CMD (see 2.2.8)

2.1.12 CGMS_WR_OPS_CTRL_PT_CFM

Source: TASK_APP

Destination: TASK_CGMS

Parameters:

Type	Parameters	Description
uint8_t	opcode	Operation code for CGM specific Ops Control Point Procedure (see Table 17)
uint8_t	rsp	CGM Specific Ops Control Point response code (see Table 27)

union cgmp_ops_ operand	operand	CGM Control Point operand related to CGM Control Point Opcode (see Table 18)

Response: None

Description: This message shall be sent by application after receiving a CGSM_WR_OPS_CTRL_PT_REQ_IND (see 2.1.11).

2.1.13 CGMS_CMP_EVT

Source: TASK_CGMS

Destination: TASK_APP

Parameters:

Type	Parameters	Description
uint8_t	operation	Operation code (see Table 10)
uint8_t	status	Operation status (see [7])

Response: None

Description: This message is used to inform the application that a CGMS procedure has been completed with the status code.

2.2 Client API

2.2.1 CGMC_ENABLE_REQ

Source: TASK_APP

Destination: TASK_ENVS

Parameters:

Type	Parameters	Description
uint8_t	con_type	Connection type (see Table 5)
struct cgmc_cgms_content	cgmc	Existing handle values for CGMC (see Table 6)

Response: CGMC_ENABLE_RSP (see 2.2.2)

Description: This API message is used for enabling the Collector role of the Continuous Glucose Monitoring profile. This application message contains BLE connection handle, the connection type and the previously saved discovered CGMS details on peer.

The connection type may be 0 = Connection for discovery/initial configuration or 1 = Normal connection. This parameter is used by application to discover peer device services once at first connection. Application shall save information to reuse them for other connections. During normal connection, previously discovered information can be reused.

This is useful since most use cases allow Sensor to disconnect the link once all measurements have been sent to Collector.

If it is a discovery /configuration type of connection, the CGMS parameters are useless; they will be filled with 0's.

Otherwise, the CGMS will contain pertinent data that will be kept in the Collector environment while enabled. It allows for the application operate transparently to attribute details.

For a normal connection, the response to this request is sent straight after saving the CGMS content in the environment and registering CGMS in GATT to receive the indications for the CGM Measurement handle in CGMS that would be indicated. For a discovery connection, discovery of the peer CGMS is started and the response will be sent at the end of the discovery with the discovered attribute details

2.2.2 CGMC_ENABLE_RSP

Source: TASK_CGMC

Destination: TASK_APP

Parameters:

Type	Parameters	Description
uint8_t	status	Outcome of the CGMC_ENABLE_RSP, indicating success failure (see [7])
struct cgmc_cgms_content	cgmc	Existing handle values for CGMS. (see Table 6)

Response: None

Description: Response to the CGMC_ENABLE_REQ (see 2.2.1) that indicates the outcome of the request.

2.2.3 CGMC_READ_CMD

Source: TASK_APP

Destination: TASK_CGMC

Parameters:

Type	Parameters	Description
uint8_t	operation	Characteristic to read: - CGMC_OP_CODE_READ_FEATURES = 1 - CGMC_OP_CODE_READ_STATUS = 2 - CGMC_OP_CODE_READ_SESSION_START_TIME = 3 - CGMC_OP_CODE_READ_SESSION_RUN_TIME = 4

Response: CGMC_VALUE_IND (see 2.2.9) / CGMC_CMP_EVT (see 2.2.11)

Description: This message is used to read the specific characteristic (indicated in the parameter) in the peer device database.

2.2.4 CGMC_READ_CCC_CMD

Source: TASK_APP

Destination: TASK_CGMC

Parameters:

Type	Parameters	Description
uint8_t	operation	CCC of specific characteristic to read: - CGMC_OP_CODE_MEASUREMENT = 11 - CGMC_OP_CODE_RACP = 12 - CGMC_OP_CODE_SPECIFIC_OPS_CTRL_PT = 13

Response: CGMC_RD_CHAR_CCC_IND (see 2.2.10) / CGMC_CMP_EVT (see 2.2.11)

Description: This message is used to read the CCC of specific characteristic (indicated in the parameter) in the peer device database.

2.2.5 CGMC_WRITE_SESS_START_TIME_CMD

Source: TASK_APP

Destination: TASK_CGMC

Parameters:

Type	Parameters	Description
struct prf_date_time	sess_start_time	The time of the initial CGM measurement (see Table 3)
int8_t	time_zone	Offset from UTC in number of 15 minutes increments (-48..+56)
uint8_t	dst_offset	Daylight Saving Time Offset - CGM_DST_OFFSET_STANDARD_TIME = 0 - CGM_DST_OFFSET_HALF_AN_HOUR_DAYLIGHT_TIME = 2 - CGM_DST_OFFSET_DAYLIGHT_TIME - CGM_DST_OFFSET_DOUBLE_DAYLIGHT_TIME =8 - CGM_DST_OFFSET_UNKNOWN_DAYLIGHT_TIME = 255

Response: CGMC_VALUE_IND (see 2.2.9) / CGMC_CMP_EVT (see 2.2.11)

Description: This message is used to read the specific characteristic (indicated in the parameter) in the peer device database.

2.2.6 CGMC_CFG_CCC_CMD

Source: TASK_APP

Destination: TASK_CGMC

Parameters:

Type	Parameters	Description
uint8_t	operation	Characteristics which have CCC Descriptor: - CGMC_OP_CODE_MEASUREMENT = 10 - CGMC_OP_CODE_RACP_CMD = 11 - CGMC_OP_CODE_SPECIFIC_OPS_CTRL_PT = 12
uint16_t	ccc	Client Characteristic Configuration value (see Table 4)

Response: CGMC_CMP_EVT (see 2.2.11)

Description: This message allows configuring the internal state of enabled CCC for specific characteristic in the peer device database. The peer device will be informed by CGMS_WR_CHAR_CCC_IND (see 2.1.8) of the configuration.

2.2.7 CGMC_WRITE_RACP_CMD

Source: TASK_APP

Destination: TASK_CGMC

Parameters:

Type	Parameters	Description
uint8_t	operation	Write Command of the Record Access Control Point: - CGMC_OP_CODE_RACP_CMD = 11

uint8_t	cp_opcode	Record Access Control Point Op codes (see Table 24)
uint8_t	cp_operator	Record Access Control Point Operators (see Table 25)
uint8_t	filter_type	Filter type: - CGMP_FILTER_TIME_OFFSET = 1
uint16_t	min_time_offset	Operand minimum filter value
uint16_t	max_time_offset	maximum filter value

Response: CGMC_CMP_EVT (see 2.2.11)

Description: This message is used to make Server do a specific operation according to Op code, operator and Operand (time_offset). The Server will be informed about this command and send CGMS_WR_RACP_IND (see 2.1.9) to the application.

2.2.8 CGMC_WRITE_OPS_CTRL_PT_CMD

Source: TASK_APP

Destination: TASK_CGMC

Parameters:

Type	Parameters	Description
uint8_t	operation	Write Command of the Specific Ops Control Point: - CGMC_OP_CODE_SPECIFIC_OPS_CTRL_PT = 12
uint8_t	opcode	Specific Ops Control Point Op codes (see Table 17)
uint8_t	response	Specific Ops Control Point response codes (see Table 27)
union cgmp_ops_operand	operand	Operand specific to opcode (see Table 18)

Response: CGMC_CMP_EVT (see 2.2.11)

Description: This message is used to write to the CGM Specific Ops Control Point to request a desired CGM Specific procedure at the Server. The Server will be informed about this command and send CGMS_WR_OPS_CTRL_PT_REQ_IND (see 2.1.11) to the application.

2.2.9 CGMC_VALUE_IND

Source: TASK_CGMC

Destination: TASK_APP

Parameters:

Type	Parameters	Description
uint8_t	operation	Operation code of characteristics to indicate: - CGMC_OP_CODE_READ_FEATURES = 1 - CGMC_OP_CODE_READ_STATUS = 2 - CGMC_OP_CODE_READ_SESSION_START_TIME = 3 - CGMC_OP_CODE_READ_SESSION_RUN_TIME = 4 - CGMC_OP_CODE_MEASUREMENT = 11 - CGMC_OP_CODE_RACP_CMD = 12 - CGMC_OP_CODE_SPECIFIC_OPS_CTRL_PT = 13
union cgmc_meas_value_tag	value	Content of indication (see Table 28)

Response: None

Description: This message is used to inform the application about specific characteristic value.

2.2.10 CGMC_RD_CHAR_CCC_IND

Source: TASK_CGMC

Destination: TASK_APP

Parameters:

Type	Parameters	Description
uint16_t	ind_cfg	Client Characteristic Configuration value to inform (see Table 4)

Response: None

Description: This message is used to inform the application about CCC read value by CGMC_READ_CCC_CMD (see 2.2.4).

2.2.11 CGMC_CMP_EVT

Source: TASK_CGMC

Destination: TASK_APP

Parameters:

Type	Parameters	Description
uint8_t	operation	Operation code • CGMC_OP_CODE_READ_FEATURES = 1 • CGMC_OP_CODE_READ_STATUS = 2 • CGMC_OP_CODE_READ_SESSION_START_TIME = 3 • CGMC_OP_CODE_READ_SESSION_RUN_TIME = 4 • CGMC_OP_CODE_READ_CCC = 5 • CGMC_OP_CODE_WRITE_SESSION_START_TIME = 6 • CGMC_OP_CODE_WRITE_CCC = 7 • CGMC_OP_CODE_WRITE_CTRL_PT = 8 • CGMC_OP_CODE_WRITE_OPS_CTRL_PT = 9 • CGMC_OP_CODE_GATTC_REGISTER = 10 • CGMC_OP_CODE_MEASUREMENT = 11 • CGMC_OP_CODE_RACP_CMD = 12 • CGMC_OP_CODE_SPECIFIC_OPS_CTRL_PT = 13
uint8_t	status	Indicates success or failure of the operation (see [7])

Response: None

Description: This message is used to inform the application that a CGMC procedure has been completed with the status code.

3 Miscellaneous

Type	Parameters	Description
uint16_t	year	Year
uint8_t	month	Month
uint8_t	day	Day
uint8_t	hour	Hour
uint8_t	min	Minutes
uint8_t	sec	Seconds

Table 3 – Time Stamp structure (struct prf_date_time)

Name	Value	Description
PRF_CLI_STOP_NTFIND	0x0000	Stop notification (bit 0) and indication (bit 1)
PRF_CLI_START_NTF	0x0001	Start notification (bit 0)
PRF_CLI_START_IND	0x0010	Start indication (bit 1)

Table 4 – Client Characteristic Configuration value

Name	Value	Description
PRF_CON_DISCOVERY	0x00	First discovery
PRF_CON_NORMAL	0x01	Normal connection

Table 5 – Connection type

Type	Parameters	Description
struct prf_svc	svc	The start and end handles for the CGMS. (see Table 7)
struct prf_char_inf	chars[2]	Array of two structures which describe the CGM Feature Characteristic and the CGM Measurement Characteristic (see Table 8)
struct prf_char_desc_inf	descs[3]	Client Characteristic Configuration descriptor: - CGMC_DESC_MEAS_CCC = 0 - CGMC_DESC_RACP_CCC = 1 - CGMC_DESC_SPEC_OPS_CTRL_PT_CCC = 2 (see Table 9)

Table 6 – Continuous Glucose Monitoring Service content structure (struct cgmc_cgms_content)

Type	Parameters	Description
uint16_t	shdl	Start handle of the Service
uint16_t	ehdl	End handle of the Service

Table 7 – Service description structure (struct prf_svc)

Type	Parameters	Description
uint16_t	char_hdl	Characteristic declaration attribute handle
uint16_t	val_hdl	Characteristic value attribute handle
uint8_t	prop	Properties
uint8_t	char_ehdl_off	Number of attribute within the Characteristic

Table 8 – Characteristic description structure (struct prf_char_inf)

Type	Parameters	Description
uint16_t	desc_hdl	Descriptor attribute handle

Table 9 – Descriptor description structure (struct prf_char_desc_inf)

Name	Value	Description
CGMS_MEAS_CMD_OP_CODE	1	CGMS Measurement operation
CGMS_OPS_CTRL_PT_OP_CODE	2	Special Ops Control Point operation
CGMS_RACP_CMD_OP_CODE	3	RACP operation
CGMS_RD_CHAR_OP_CODE	4	Read Characteristic operation

Table 10 – Operation codes for Complete Event Command

Bit	Name	Description
0	CGM_MEAS_FLAGS_CGM_TREND_INFO	CGM Trend Information Field: 0 for not present; 1 for present
1	CGM_MEAS_FLAGS_CGM_QUALITY	CGM Quality Field: 0 for not present; 1 for present
5	CGM_MEAS_FLAGS_SENSOR_STATUS_ANNUNC_WARN	Sensor Status Annunciation Field – Warning: 0 for not present; 1 for present
6	CGM_MEAS_FLAGS_SENSOR_STATUS_ANNUNC_CAL_TEMP	Sensor Status Annunciation Field - Cal/Temp: 0 for not present; 1 for present
7	CGM_MEAS_FLAGS_SENSOR_STATUS_ANNUNC_STATUS	Sensor Status Annunciation Field – Status: 0 for not present; 1 for present

Table 11– CGM Measurement Flags bit field

Size	Type
4 bits	Exponent
12 bits	Mantissa

Table 12– Structure of prf_sfloat (uint16_t)

Status byte		
Bit	**Name**	**Description**
0	CGM_MEAS_ANNUNC_STATUS_SESS_STOPPED	Session Stopped Field: 0 for not present; 1 for present
1	CGM_MEAS_ANNUNC_STATUS_DEV_BATT_LOW	Device Battery Low Field: 0 for not present; 1 for present
2	CGM_MEAS_ANNUNC_STATUS_SENSOR_TYPE_INCOR	Sensor type incorrect for device Field: 0 for not present; 1 for present
3	CGM_MEAS_ANNUNC_STATUS_SENSOR_MALFUNC	Sensor malfunction Field: 0 for not present; 1 for present
4	CGM_MEAS_ANNUNC_STATUS_DEV_SPEC_ALERT	Device Specific Alert Field: 0 for not present; 1 for present
5	CGM_MEAS_ANNUNC_STATUS_GEN_DEV_FAULT	General device fault has occurred in the sensor Field: 0 for not present; 1 for present
6	RFU	Reserved for Future Use
7	RFU	Reserved for Future Use

Cal/Temp byte		
Bit	**Name**	**Description**
0	CGM_MEAS_ANNUNC_CAL_TEMP_TIME_SYNC_REQ	Time synchronization between sensor and collector required Field: 0 for not present; 1 for present
1	CGM_MEAS_ANNUNC_CAL_TEMP_CALIB_NOT_ALLOWED	Calibration not allowed Field: 0 for not present; 1 for present
2	CGM_MEAS_ANNUNC_CAL_TEMP_CALIB_RECMD	Calibration recommended Field: 0 for not present; 1 for present
3	CGM_MEAS_ANNUNC_CAL_TEMP_CALIB_REQ	Calibration required Field: 0 for not present; 1 for present
4	CGM_MEAS_ANNUNC_CAL_TEMP_SENSOR_TEMP_HIGH	Sensor Temperature too high for valid test/result at time of measurement Field: 0 for not present; 1 for present
5	CGM_MEAS_ANNUNC_CAL_TEMP_SENSOR_TEMP_LOW	Sensor Temperature too low for valid test/result at time of measurement Field: 0 for not present; 1 for present
6	RFU	Reserved for Future Use
7	RFU	Reserved for Future Use
Warning byte		
Bit	**Name**	**Description**
0	CGM_MEAS_ANNUNC_WARN_SENSOR_RES_LOWER_PAT	Sensor result lower than the Patient High level Field: 0 for not present; 1 for present
1	CGM_MEAS_ANNUNC_WARN_SENSOR_RES_HIGHER_PAT	Sensor result higher than the Patient High level Field: 0 for not present; 1 for present
2	CGM_MEAS_ANNUNC_WARN_SENSOR_RES_LOWER_HYPO	Sensor result lower than the Hypo level Field: 0 for not present; 1 for present
3	CGM_MEAS_ANNUNC_WARN_SENSOR_RES_HIGHER_HYPER	Sensor result higher than the Hyper level Field: 0 for not present; 1 for present
4	CGM_MEAS_ANNUNC_WARN_SENSOR_RATE_DECR	Sensor Rate of Decrease exceeded Field: 0 for not present; 1 for present
5	CGM_MEAS_ANNUNC_WARN_SENSOR_RATE_INCR	Sensor Rate of Increase exceeded Field: 0 for not present; 1 for present
6	CGM_MEAS_ANNUNC_WARN_SENSOR_RES_LOWER_DEV	Sensor result lower than the device can process Field: 0 for not present; 1 for present
7	CGM_MEAS_ANNUNC_WARN_SENSOR_RES_HIGHER_DEV	Sensor result higher than the device can process Field: 0 for not present; 1 for present

Table 13 – Sensor Status Annunciation bit field

Type	Parameters	Description
uint16_t	time_offset	The relative time difference of the single CGM values to the session start time (in minutes)
uint8_t	warning	Sensor Status Annunciation warning byte (see Table 13)

uint8_t	cal_temp	Sensor Status Annunciation Calibration/Temperature byte (see Table 13)
uint8_t	annunc_status	Sensor Status Annunciation Status byte (see Table 13)

Table 14 – CGMS Read Status structure (struct cgms_rd_status)

Type	Parameters	Description
struct prf_date_time	sess_start_time	The time of the initial CGM measurement (see Table 3)
int8_t	time_zone	Offset from UTC in number of 15 minutes increments (-48..+56)
uint8_t	dst_offset	Daylight Saving Time Offset - CGM_DST_OFFSET_STANDARD_TIME = 0 - CGM_DST_OFFSET_HALF_AN_HOUR_DAYLIGHT_TIME = 2 - CGM_DST_OFFSET_DAYLIGHT_TIME - CGM_DST_OFFSET_DOUBLE_DAYLIGHT_TIME =8 - CGM_DST_OFFSET_UNKNOWN_DAYLIGHT_TIME = 255

Table 15 – CGMS Read Session Start Time structure (struct cgms_rd_sess_start_time)

Type	Parameters	Description
uint16_t	run_time	Run time in minutes

Table 16 – CGM Read Run Time structure (struct cgms_rd_sess_run_time)

Value	Name	Description
1	CGMP_OPS_CODE_SET_CGM_COM_INTVL	Set CGM communication interval
2	CGMP_OPS_CODE_GET_CGM_COM_INTVL	Get CGM communication interval
3	CGMP_OPS_CODE_CGM_COM_INTVL_RSP	Communication interval response
4	CGMP_OPS_CODE_SET_GLUC_CALIB_VALUE	Set Glucose Calibration value
5	CGMP_OPS_CODE_GET_GLUC_CALIB_VALUE	Get Glucose Calibration value
6	CGMP_OPS_CODE_GLUC_CALIB_VALUE_RSP	Glucose Calibration value
7	CGMP_OPS_CODE_SET_PAT_HIGH_ALERT_LEVEL	Set Patient High Alert Level
8	CGMP_OPS_CODE_GET_PAT_HIGH_ALERT_LEVEL	Get Patient High Alert Level
9	CGMP_OPS_CODE_PAT_HIGH_ALERT_LEVEL_RSP	Patient High Alert Level response
10	CGMP_OPS_CODE_SET_PAT_LOW_ALERT_LEVEL	Set Patient Low Alert Level
11	CGMP_OPS_CODE_GET_PAT_LOW_ALERT_LEVEL	Get Patient Low Alert Level
12	CGMP_OPS_CODE_PAT_LOW_ALERT_LEVEL_RSP	Patient Low Alert Level response
13	CGMP_OPS_CODE_SET_HYPO_ALERT_LEVEL	Set Hypo Alert Level
14	CGMP_OPS_CODE_GET_HYPO_ALERT_LEVEL	Get Hypo Alert Level
15	CGMP_OPS_CODE_HYPO_ALERT_LEVEL_RSP	Hypo Alert Level response
16	CGMP_OPS_CODE_SET_HYPER_ALERT_LEVEL	Set Hyper Alert Level
17	CGMP_OPS_CODE_GET_HYPER_ALERT_LEVEL	Get Hyper Alert Level
18	CGMP_OPS_CODE_HYPER_ALERT_LEVEL_RSP	Hyper Alert Level response

19	CGMP_OPS_CODE_SET_RATE_OF_DECR_ALERT_LEVEL	Set Rate of Decrease Alert Level
20	CGMP_OPS_CODE_GET_RATE_OF_DECR_ALERT_LEVEL	Get Rate of Decrease Alert Level
21	CGMP_OPS_CODE_RATE_OF_DECR_ALERT_LEVEL_RSP	Rate of Decrease Alert Level Response
22	CGMP_OPS_CODE_SET_RATE_OF_INCR_ALERT_LEVEL	Set Rate of Increase Alert Level
23	CGMP_OPS_CODE_GET_RATE_OF_INCR_ALERT_LEVEL	Get Rate of Increase Alert Level
24	CGMP_OPS_CODE_RATE_OF_INCR_ALERT_LEVEL_RSP	Rate of Increase Alert Level Response
25	CGMP_OPS_CODE_RESET_DEV_SPEC_ALERT	Reset Device Specific Alert
26	CGMP_OPS_CODE_START_SESS	Start Session
27	CGMP_OPS_CODE_STOP_SESS	Stop Session
28	CGMP_OPS_CODE_RSP_CODE	Response

Table 17 – CGM Ops Control Point OpCode

Type	Parameters	Description
uint16_t	intvl	Communication interval in minutes
struct cgm_calib_operand	calib	Operand value as defined in the Calibration value Fields (see Table 19)
uint16_t	cal_data_record_number	Calibration Data Record Number
prf_sfloat	pat_high_bg	Patient High bG value in mg/dL (see Table 12)
prf_sfloat	pat_low_bg	Patient Low bG value in mg/dL (see Table 12)
prf_sfloat	hypo_alert_level	Hyper Alert Level value in mg/dL (see Table 12)
prf_sfloat	hyper_alert_level	Hyper Alert Level value in mg/dL (see Table 12)
prf_sfloat	rate_decr_alert_level	Rate of Decrease Alert Level value in mg/dL/min (see Table 12)
prf_sfloat	rate_incr_alert_level	Rate of Increase Alert Level value in mg/dL/min (see Table 12)
struct req_op_code	req_rsp_value	Request Op code, Response Code value see (Table 20)

Table 18 – CGMP Ops Operand union (union cgmp_ops_operand)

Type	Parameters	Description
prf_sfloat	cal_gluc_concent	Glucose Concentration at Calibration (see Table 12)
uint16_t	cal_time	Calibration Time in minutes
uint8_t	cal_type_spl	Calibration Type of Sample (see Table 21)
uint8_t	cal_spl_loc	Calibration Location of Sample (see Table 22)
uint16_t	next_cal_time	Next Calibration Time in minutes
uint16_t	cal_record_num	Calibration Record Number
uint8_t	cal_status	Calibration Status (see Table 23)

Table 19 – CGM Calibration Operand value structure (structure cgm_calib_oprand)

Type	Parameters	Description
uint8_t	req_op_code	Request Op Code
uint8_t	rsp_code	Response code value

Table 20 – Request Op code and Response Code structure (struct req_op_code)

Value	Name	Description
1	CGM_TYPE_SMP_CAPILLARY_WHOLE_BLOOD	Capillary whole blood
2	CGM_TYPE_SMP_CAPILLARY_PLASMA	Capillary Plasma
3	CGM_TYPE_SMP_CAPILLARY_WHOLE_BLOOD_2	Capillary whole blood 2
4	CGM_TYPE_SMP_VENOUS_PLASMA	Venous plasma
5	CGM_TYPE_SMP_ARTERIAL_WHOLE_BLOOD	Arterial whole blood
6	CGM_TYPE_SMP_ARTERIAL_PLASMA	Arterial plasma
7	CGM_TYPE_SMP_UNDETERMINED_WHOLE_BLOOD	Undetermined whole blood
8	CGM_TYPE_SMP_UNDETERMINED_PLASMA	Undetermined plasma
9	CGM_TYPE_SMP_INTERSTITIAL_FLUID	Interstitial fluid
10	CGM_TYPE_SMP_CONTROL_SOLUTION	Control solution

Table 21 – Calibration Sample type ID enumeration

Value	Name	Description
1	CGM_SMP_LOC_FINGER	Finger
2	CGM_SMP_LOC_ALTERNATE_SITE_TEST	Alternate site test
3	CGM_SMP_LOC_EARLOBE	Earlobe
4	CGM_SMP_LOC_CONTROL_SOLUTION	Control solution
5	CGM_SMP_LOC_SUBCUTANEOUS_TISSUE	Subcutaneous tissue
15	CGM_SMP_LOC_LOCATION_NOT_AVAILABLE	Location not available

Table 22 – Calibration Location of Sample enumeration

Bit	Name	Description
0	CGMP_CAL_STATUS_DATA_REJECTED	Calibration Data rejected (Calibration failed) 0 for false; 1 for true
1	CGMP_CAL_STATUS_DATA_OUT_RANGE	Calibration Data out of range 0 for false; 1 for true
2	CGMP_CAL_STATUS_PROCESS_PENDING	Calibration Process Pending 0 for false; 1 for true

Table 23 – Calibration status bit field

Bit	Name	Description
1	CGMP_OPCODE_REP_STRD_RECS	Report Stored Records
2	CGMP_OPCODE_DEL_STRD_RECS	Delete Stored Records
3	CGMP_OPCODE_ABORT_OP	Abort Operation
4	CGMP_OPCODE_REP_NUM_OF_STRD_RECS	Report Number Of Stored Records
5	CGMP_OPCODE_NUM_OF_STRD_RECS_RSP	Number of Stored Records Response
6	CGMP_OPCODE_RSP_CODE	Response Code

Table 24 – Control Point Op Codes

Bit	Name	Description
0	CGMP_OP_NULL	Null Operation
1	CGMP_OP_ALL_RECS	All records
2	CGMP_OP_LT_OR_EQ	Less than or equal
3	CGMP_OP_GT_OR_EQ	Greater than or equal to
4	CGMP_OP_WITHIN_RANGE_OF	Within range of (inclusive)
5	CGMP_OP_FIRST_REC	First record (i.e. oldest record)

6	CGMP_OP_LAST_REC	Last record (i.e. most recent record)

Table 25 – Control Point Operators

Bit	Name	Description
1	CGMP_RSP_SUCCESS	Success
2	CGMP_RSP_OP_CODE_NOT_SUP	Not supported
3	CGMP_RSP_INV_OPERATOR	Invalid Operator
4	CGMP_RSP_OPERATOR_NOT_SUP	Operator not supported
5	CGMP_RSP_INV_OPERAND	Invalid Operand
6	CGMP_RSP_NO_RECORDS_FOUND	No records found
7	CGMP_RSP_ABORT_UNSUCCESSFUL	Abort unsuccessful
8	CGMP_RSP_PROC_NOT_CMP	Procedure not completed
9	CGMP_RSP_OPERAND_NOT_SUP	Operand not supported

Table 26 – Control Point Response Code values

Bit	Name	Description
1	CGMP_OPS_RSP_SUCCESS	Success Normal response for successful operation
2	CGMP_OPS_RSP_OP_CODE_NOT_SUP	Not supported Normal response if unsupported Op Code is received
3	CGMP_OPS_RSP_INV_OPERAND	Invalid Operand Normal response if Operand received does not meet the requirements of the service
4	CGMP_RSP_PROC_NOT_CMP	Procedure not completed Normal response if unable to complete a procedure for any reason
5	CGMP_RSP_PARAM_OUT_OF_RANGE	Parameters out of range Normal response if Operand received does not meet the range requirements

Table 27 – Specific Ops Control Point Response code

Type	Parameters	Description
struct cgmc_meas_value	meas	Measurement value (see Table 29)
struct cgmc_racp_rsp	racp_rsp	Record Access Control Point response (see Table 30)
struct cgmc_ops_ctrl_pt_rsp	ops_cp_rsp	Specific Ops Control Point response (see Table 31)
struct cgmc_rd_feat_value	feat	CGM Feature (see Table 32)
struct cgmc_rd_status	status	CGM Status (see Table 33)
struct cgmc_rd_sess_start_time	start_time	CGM Session Start Time (see Table 34)
struct cgmc_rd_sess_run_time	run_time	CGM Session Run Time (see Table 35)

Table 28 – CGMC value union (union cgmc_meas_value_tag)

Type	Parameters	Description
uint8_t	size	CGM Measurement record size
uint8_t	flags	Selects the valid contents of the message – if field is not selected in the flags field - it will not be transmitted to the collector. (see Table 11)
prf_sfloat	gluc_concent	CGM Glucose Concentration in mg/dL (see Table 12)

uint16_t	time_offset	The relative time difference of the single CGM values to the session start time in minutes
uint8_t	warn	Warning octet of Sensor Status Annunciation (see Table 13)
uint8_t	cal_temp	Calibration and temperature octet of Sensor Status Annunciation (see Table 13)
uint8_t	status	Status octet of Sensor Status Annunciation (see Table 13)
prf_sfloat	trend_info	CGM Trend Information in (mg/dL)/min as a SFLOAT data type (see Table 12)
prf_sfloat	quality	CGM Quality in percentage as a SFLOAT data type (see Table 12)

Table 29 – CGM Measurement value (struct cgmc_meas_value)

Type	Parameters	Description
uint8_t	cp_opcode	Control Point Opcode (see Table 25)
uint8_t	req_cp_opcode	Request Control Point Opcode (see Table 25)
uint8_t	rsp_code	Response Code (see Table 26)
uint16_t	records_num	Number of records

Table 30 – Record Access Control Point response (struct cgmc_racp_rsp)

Type	Parameters	Description
uint8_t	opcode	Control Point Opcode (see Table 17)
uint8_t	response	Op-code Response (see Table 27)
union cgmp_ops_operand	operand	Operand specific to opcode (see Table 18)

Table 31 – Specific Ops Control Point response (struct cgmc_ops_ctrl_pt_rsp)

Type	Parameters	Description
uint32_t	cgm_feature	CGM Feature value (see Table 2)
uint8_t	type_samp	Type of sample (see Table 21)
uint8_t	samp_loc	Location of sample (see Table 22)

Table 32 – CGM Feature value (struct cgmc_rd_feat_value)

Type	Parameters	Description
uint16_t	time_offset	The relative time difference of the single CGM values to the session start time in minutes
uint8_t	warning	Sensor Status Annunciation warning byte (see Table 13)
uint8_t	cal_temp	Sensor Status Annunciation Calibration/Temperature byte (see Table 13)
uint8_t	annunc_status	Sensor Status Annunciation Status byte (see Table 13)

Table 33 – CGM Status (struct cgmc_rd_status)

Type	Parameters	Description
struct prf_date_time	sess_start_time	The time of the initial CGM measurement (see Table 3)
int8_t	time_zone	Offset from UTC in number of 15 minutes increments (-48..+56)
uint8_t	dst_offset	Daylight Saving Time Offset - CGM_DST_OFFSET_STANDARD_TIME = 0 - CGM_DST_OFFSET_HALF_AN_HOUR_DAYLIGHT_TIME = 2 - CGM_DST_OFFSET_DAYLIGHT_TIME

		- CGM_DST_OFFSET_DOUBLE_DAYLIGHT_TIME =8 - CGM_DST_OFFSET_UNKNOWN_DAYLIGHT_TIME = 255

Table 34 – CGM Session Start Time (struct cgmc_rd_sess_start_time)

Type	Parameters	Description
uint16_t	run_time	Run time in minutes

Table 35 – CGM Session Run Time (struct cgmc_rd_sess_run_time)

4 Abbreviations

Abbreviation	Original Terminology
API	Application Programming Interface
BLE	Bluetooth Low Energy
CCC	Client Characteristic Configuration
GAP	Generic Access Profile
GATT	Generic Attribute Profile
MSC	Message Sequence Chart
CGMP	Continuous Glucose Monitoring Profile
CGMS	Continuous Glucose Monitoring Service
RW	RivieraWaves

5 References

[1]	**Title**	Continuous Glucose Monitoring Profile – Bluetooth Profile Specification		
	Reference	CGMP_v1.0.1		
	Version	1.0.1	**Date**	2015-12-15
	Source	Bluetooth SIG		

[2]	**Title**	Continuous Glucose Monitoring Service – Bluetooth Service Specification		
	Reference	CGMS_v1.0.1		
	Version	1.0.1	**Date**	2015-12-15
	Source	Bluetooth SIG		

[3]	**Title**	Continuous Glucose Monitoring Profile – Bluetooth Test Specification		
	Reference	CGMP.TS.1.0.1.2		
	Version	1.0.1.2	**Date**	2017-11-28
	Source	Bluetooth SIG		

[4]	**Title**	Continuous Glucose Monitoring Service – Bluetooth Test Specification		
	Reference	CGMS.TS.1.0.1.2		
	Version	1.0.1.2	**Date**	2016-12-13
	Source	Bluetooth SIG		

[5]	**Title**	RW BLE Device Information Service Interface Specification		
	Reference	RW_BLE_PRF_DIS_IS		
	Version	9.1	**Date**	2019-09-05
	Source	RivieraWaves		

[6]	**Title**	GAP Interface Specification		
	Reference	RW-BLE-GAP-IS		
	Version	9.15	**Date**	2019-04-02
	Source	RivieraWaves		

[7]	**Title**	RW BLE Host Error Code Interface Specification		
	Reference	RW-BLE-HOST-ERR-CODE-IS		
	Version	9.1	**Date**	2018-10-24
	Source	RivieraWaves		