CORE SENSOR - Core Body Temperature Service Specification

Bluetooth® Low Energy (BLE) GATT Service Specification

V2.1

Revision Number	Date	Comments
V1.0	2021-10-01	Initial draft based on the Fitness Machine Service of Bluetooth® SIG
V1.1	2021-12-06	Extended CoreTemp Control point, added battery service as complementary service, fixed contradictory 'quality and state' bit assignment, fixed spelling mistakes.
V1.2	2022-02-02	Add missing UUID information for CoreTemp Control point, reformatting.
V2.0	2023-07-28	Update Control Point OpCodes and Procedures for Bluetooth Heart Rate Monitors, changes in ANT+ Heart Rate Monitor Procedures. Add instructions about scanning procedures.
V2.1	2023-10-16	Update Core Temperature Service Payload structure: Add Heart Rate value.

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1 Introduction

1.1 Byte Transmission Order

All characteristics used with this service shall be transmitted with the least significant octet first (i.e., little endian).

2 Service Declaration

The Core Body Temperature Service shall be instantiated as a “Primary Service”.

The service UUID shall be set to the custom UUID 00002100-5B1E-4347-B07C-97B514DAE121.

2.1 Byte Ordering

Where characteristics and descriptors are comprised of multiple bytes (shown in several tables within this document), the Least Significant Octet (LSO) is defined as the eight low-numbered bits (i.e., bits 0 to 7) of the topmost field in the tables. The Most Significant Octet (MSO) is defined as the high-numbered bits of the bottommost field in the tables.

3 Service Characteristics

The following characteristics are exposed in the Core Body Temperature Service. Unless otherwise specified, only one instance of each characteristic is permitted within this service.

Characteristic Name	Requirement	Mandatory Properties	Optional Properties	Security Permissions
Core Body Temperature	M	Read	Notify	None.
Client Characteristic Configuration descriptor	C.1	Read, Write		None.
CoreTemp Control Point	M	Write, Indicate		None
Client Characteristic Configuration descriptor	M	Read, Write		None.

C.1 Mandatory, if Notify is supported, otherwise excluded.

Table 1 Core Body Temperature Service characteristics.

3.1 Core Body Temperature

The Core Body Temperature characteristic is used to send a body temperature measurement. Included in the characteristic are a Flags field (for showing the units of the temperature and presence of optional fields), and, depending on the contents of the Flags filed, the temperature measurement value and the data quality of that temperature measurement.

	LSO					MSO
	Flags	Core Body Temperature	Skin Temperature (if present)	Core reserved (if present)	Quality and State (if present)	Heart Rate (if present)
Octet Order	N/A	LSO…MSO	LSO…MSO	LSO…MSO	N/A	N/A
Data type	8bit	SINT16	SINT16	SINT16	8bit	8bit
Size	1 octet	2 Octets	2 octets	2 octets	1 octet	1 octet
Units	None	0.01°C *or* 0.01°F[1)]	0.01°C *or* 0.01°F[1)]	None	None	BPM

[1)] Temperature unit is encoded in Flags field as defined in 3.1.1.1.

Table 2 Structure of the Core Body Temperature characteristic.

3.1.1 Characteristic Behavior

When *the Client Characteristic Configuration* descriptor is configured for notification and a temperature measurement is available, this characteristic shall be notified while in a connection.

If a temperature measurement is available and a connection is not currently established, the Server shall become connectable to allow the Collector to create a link.

The UUID for this characteristic shall be set to UUID 00002101-5B1E-4347-B07C-97B514DAE121.

3.1.1.1 Flags field

The Flags field shall be included in the Core Body Temperature Characteristic. Reserved for Future Use (RFU) bits in the Flags field shall be set to 0.

The bits of the Flags are shown in Table 3.

Bit Number	Flags Bit Name	When set to 0	When set to 1
0	Skin Temperature	Corresponding field *not* present	Corresponding field present
1	Core Reserved	Corresponding field *not* present	Corresponding field present
2	Quality and State	Corresponding field *not* present	Corresponding field present
3	Temperature Unit	Unit of Temperature field is in °C	Unit of Temperature field is in °F
4	Heart Rate	Corresponding field *not* present	Corresponding field present
5-7	*Reserved for Future use*	*shall be set to 0*	-

Table 3 Bit definitions of the Flags field for the Core Body Temperature Characteristic.

3.1.1.2 Core Body Temperature field

The Core Body Temperature field is mandatory for the Core Body Temperature characteristic. It represents the current core body temperature. If there is currently no valid reading available, the server shall send the special value 0x7FFF (i. e., decimal value of 32767 in SINT 16 format), which means 'Data not available'. The information encoded in the Quality and State field (3.1.1.5) may give further indications why no data is available currently.

3.1.1.3 Skin Temperature field

The presence of the Skin Temperature field is indicated by the corresponding bit in the flag field. It represents the current skin temperature, which may be measured along the core body temperature by a device implementing the Core Body Temperature Service.

3.1.1.4 Core Reserved field

The presence of the Core Reserved field is indicated by the corresponding bit in the flag field.

3.1.1.5 Quality and State field

The presence of the Quality and State field is indicated by the corresponding bit in the flag field. It may be used to indicate the quality or trust level of the current measurement values (bit 0-3).

Bit Number	Description	Value
0-3	Data Quality	Bit 2-0: Bits set to 000 – Invalid Bits set to 001 – Poor Bits set to 010 – Fair Bits set to 011 – Good Bits set to 100 – excellent Bits set to 111 – N/A (*Data Quality is not available*) Bit 3 – *reserved, shall be set to 0*
4-7	State	Bit 5-4: Bit set to 00 – Pairing with heart rate not supported Bit set to 01 – Heart rate supported, not receiving Heart Rate signal Bit set to 10 – Heart rate supported, receiving Heart Rate signal Bit set to 11 – N/A (*State of HRM is not available*) Bits 7-6 – *reserved, shall be set to 0*

Table 4 Bit Definitions for the optional Quality and State field of the Core Body Temperature Characteristic

3.1.1.6 Heart Rate field

The presence of the heart rate field is indicated by the corresponding bit in the flag. The core body temperature measurement quality can be improved a lot during high activity by pairing the sensor to a heart rate monitor. For the convenience of accessing the heart rate signal, that the sensor receives, through the Core Body Temperature BLE service, it is added along with the temperature measurement. If no heart rate signal is currently received by the sensor, the value shall be set to 0.

3.2 CoreTemp Control Point

A core body temperature sensor may expose the CoreTemp Control Point. For example, if it can pair with a heart-rate monitor (HRM), the Client can write the ID of the HRM to the device. If the core body temperature device supports pairing with a heart rate monitor, it will then implement a procedure to attempt to connect to the heart rate monitor after processing this command.

The format of the CoreTemp Control Point characteristic is defined in Table 5. The Op Codes, Parameters and requirements for the Core Control Point are defined in Section 3.2.1 below.

	LSO	MSO
	OpCode	Parameter Value
Octet Order	N/A	LSO…MSO
Data type	UINT8	Variable
Size	1 octet	0 to 6 Octets
Units	None	None

Table 5 CoreTemp Control Point characteristic

3.2.1 Characteristic Behavior

The UUID for this characteristic shall be set to UUID 00002102-5B1E-4347-B07C-97B514DAE121.

The *Client Characteristic Configuration* descriptor shall be configured for indication for the CoreTemp Control Point characteristic to indicate the result of a control procedure back to the client. The procedures are further explained in the sections below.

3.2.1.1 CoreTemp Control Point Procedures

A client shall use the *GATT Write Characteristic Value* sub-procedure to initiate a sub-procedure defined in Table 6. A special OpCode (0x80) will be used by the Peripheral to indicate the result of a sub-procedure back to the Client. Please note that therefore, this OpCode must not be sent by the client.

If the operation results in an error condition where the CoreTemp Control Point cannot be indicated, the error handling as defined in CSS Part B [1] applies. The two cases of interest are described in the next paragraphs.

If an OpCode is written to the CoreTemp Control Point characteristic while the Server is performing a previously triggered CoreTemp Control Point operation (i.e., resulting from invalid Client behavior), the Server shall return an error response with the Attribute Protocol error code set to “Procedure Already In Progress” as defined in CSS Part B.

If an Op Code is written to the CoreTemp Control Point characteristic and the Client Characteristic Configuration descriptor of the CoreTemp Control Point is not configured for indications, the Server shall return an error response with the Attribute Protocol error code set to “Client Characteristic Configuration Descriptor Improperly Configured” as defined in CSS Part B.

OpCode	Req.	Definition	Parameter Value
0x00		*Reserved for future use (RFU)*	
0x01	C.1	Clear list of ANT+ paired heart rate monitors	N/A
0x02	C.1	Add ANT+ heart rate monitor to list of paired devices	Use 3 bytes to send the ANT+ ID and the transmission type (Tx-type), where the upper nibble of the Tx-type may contain the extended Device ID. LS0 (3 Bytes) MS0 (Device ID) 2 Bytes | (Tx-type) 1 Byte
0x03	C.1	Remove ANT+ heart rate monitor from list of paired devices	Use 3 bytes to send the ANT+ ID and the transmission type (Tx-type), where the upper nibble of the Tx-type may contain the extended Device ID. LS0 (3 Bytes) MS0 (Device ID) 2 Bytes | (Tx-type) 1 Byte
0x04	C.1	Get total number of paired ANT+ heart rate monitors	N/A
0x05	C.1	Get ID of paired ANT+ heart rate monitor at index *i*.	Index *i* (UINT8) in range(0, total number of ANT+ HRMs). Details for the response parameter, see 3.2.1.2.
0x06	C.2	Add BLE heart rate monitor to list of paired devices	The full Bluetooth Address (6 bytes) of the HRM. LS0 MS0 6 Bytes
0x07	C.2	Remove BLE heart rate monitor from list of paired devices	The full Bluetooth Address (6 bytes) of the HRM. LS0 MS0 6 Bytes
0x08	C.2	Get Total number of paired BLE heart rate monitors	N/A
0x09	C.2	Get name and state of paired BLE heart rate monitor at index *i*	Index *i* (UINT8) in range(0, total number of BLE HRMs). Details for the response parameter, see 3.2.1.3.
0x0A	C.1	Scan for available ANT+ heart rate monitors.	Details for the request and response parameter, see 3.2.1.4.
0x0B	C.1	Get total number of scanned ANT+ heart rate monitors	N/A
0x0C	C.1	Get ID of scanned ANT+ heart rate monitor at index *i*.	Index *i* (UINT8) in range(0, total number of scanned ANT+ HRMs). Details for the response, see 3.2.1.5.
0x0D	C.2	Scan for available BLE heart rate monitors.	Details for the request and response parameter, see 3.2.1.6.
0x0E	C.2	Get total number of scanned BLE heart rate monitors	N/A
0x0F	C.2	Get name of scanned BLE heart rate monitor at index *i*.	Index *i* (UINT8) in range(0, total number of scanned BLE HRMs). Details for the response, see 3.2.1.7.
0x10	C.2	Get MAC of scanned BLE heart rate monitor at index *i*.	Index *i* (UINT8) in range(0, total number of scanned BLE HRMs). Details for the response, see 3.2.1.8.
0x11	C.2	Clear list of BLE paired heart rate monitors.	N/A
0x12	C.2	Get MAC and state of paired BLE heart rate monitor at index *i*.	Index *i* (UINT8) in range(0, total number of paired BLE HRMs). Details for the response, see 3.2.1.9.
0x13-0x7F		*Reserved for future use (RFU)*	
0x80	M	Used to identify the response to this Control Point.	Response Code, see section 3.2.1.10. The client must never send this OpCode.
0x81-0xFF		*Reserved for future use (RFU)*	

C.1: If the core body temperature sensor supports pairing ANT+ Heart Rate Monitors.
C.2: If the core body temperature sensor supports pairing BLE Heart Rate Monitors.
M: Mandatory.

Table 6 CoreTemp Control Point Procedure description.

3.2.1.2 Control Point ANT+ HRM Id Procedure (Op Code 0x05)

When the 'get ID of ANT+ heart rate monitor' procedure is written to the CoreTemp Control Point and the Result Code is 'Success', i.e. the heart rate monitor at index *i* is present, the Server shall include the id of the heart rate monitor and the state in the response parameter as stated in Table 7 below.

	LSO	MSO
	ANT id	State
Octet Order	LSO…MSO	N/A
Data type	Variable	N/A
Size	3 Octets	1 Octet
Details	Use 3 bytes to send the ANT+ ID and the transmission type (Tx-type), where the upper nibble of the Tx-type may contain the extended Device ID.	Bit 0-1: Bit set to 00 – HRM state is "Closed" Bit set to 01 – HRM state is "Searching" Bit set to 10 – HRM state is "Synchronized" Bit set to 11 – HRM state is "Reserved" Bit 2-7 *Reserved for future use (RFU), set to 0*

	LS0			MS0
	Byte 1	*Byte 2*	*Byte 3*	*Byte 4*
	ANT ID	ANT ID	Transmission Type	State

Table 7 Result Parameter for Result of OpCode 0x05 (id of ANT+ HRM at index).

3.2.1.3 Control Point BLE HRM Id Procedure (Op Code 0x09)

When the 'get ID of BLE heart rate monitor' procedure for paired sensors is written to the CoreTemp Control Point and the Result Code is 'Success', i.e. the heart rate monitor at index *i* is present, the Server shall include the id of the heart rate monitor and the state in the response parameter as stated in Table 8 below.

	LSO	MSO
	State	Bluetooth Local Name
Octet Order	N/A	N/A
Data type	N/A	N/A
Size	1 octet	0 to 16[1] octets
Details	Bit 0-1: Bit set to 00 – HRM state is "disconnected" Bit set to 01 – HRM state is "connected"	The Bluetooth name of the heart rate monitor, truncated at 16 bytes.

Table 8 Result Parameter for result of OpCode 0x09 (id of BLE HRM at index).

3.2.1.4 Control Point ANT+ HRM Scan Procedure (OpCode 0x0A)

When the 'Scan for available ANT+ heart rate monitors' procedure is written to the CoreTemp Control Point, the Server shall perform the respective procedure as stated below in Table 9, depending on the request parameters.

If the 'Scan for available ANT+ heart rate monitors'-procedure is successfully started, the 'CoreTemp Control Point Complete'-procedure shall be indicated by the server by sending Result Code 0x01 ('Success') without any response parameters (see 3.2.1.8). The scan will take a few seconds on the device. It is recommended to poll the total number of scanned monitors (OpCode 0x0B) in 1s intervals for a few times. When the total number doesn't change anymore, it is safe to assume that the peripheral has found all sensors in range.

[1] This is because the characteristic response should fit in a PDU smaller or equal MTU size (20 bytes).

OpCode	Request Parameter	Definition of the procedure
0x0A	0xFF	Start scanning for ANT+ HRMs on the peripheral. This shall invalidate the old / cached list from a previous scan.
0x0A	0xFE	Start scan and do proximity pairing, i.e. automatically add the HRM with the best signal strength to the list of paired devices. This shall also invalidate the old / cached list from a previous scan and only save the id of the HRM with the best signal strength in the list of scanned devices. Note: command will fail with 'operation failed' if no HRM could be found during the scan or if the list of paired HRMs is full.

Table 9 Request parameter for OpCode 0x0A (scan for list of available ANT+ HRMs).

3.2.1.5 Control Point ANT+ HRM Procedure (OpCode 0x0C)

The response for OpCode 0x0C, procedure to get ID of scanned ANT+ HRM at position *i*, is defined in Table 10.

	Device id
Octet Order	LSO…MSO
Data type	N/A
Size	3 Octets
Details	ANT+ ID of HRM at index *i* in the list of devices that were found during the scan, where the upper nibble of the transmission type may contain the extended Device ID. LSB … MSB *Byte 1* (ANT ID) | *Byte 2* (ANT ID) | *Byte 3* (Transmission Type)

Table 10 Response parameter for OpCode 0x0C.

3.2.1.6 Control Point BLE HRM Scan Procedure (OpCode 0x0D)

When the 'Scan for available BLE heart rate monitors' procedure is written to the CoreTemp Control Point, the Server shall perform the respective procedure as stated below in Table 11, depending on the request parameters.

After the 'Scan for available BLE heart rate monitors'-procedure is successfully started, the 'CoreTemp Control Point Complete'-procedure shall be indicated by the server by sending Result Code 0x01 ('Success') without any response parameters (see 3.2.1.8). The scan will take a few seconds on the device. It is recommended to poll the total number of scanned monitors (OpCode 0x0E) in 1s intervals for a few times. When the total number doesn't change anymore, it is safe to assume that the peripheral has found all sensors in range.

OpCode	Request Parameter	Definition of the procedure
0x0D	0xFF	Start scan for BLE HRMs on the peripheral. This shall invalidate the old / cached list from a previous scan.
0x0D	0xFE	Start scan and do proximity pairing, i e. automatically add the HRM with the best signal strength to the list of paired devices. This shall also invalidate the old / cached list from a previous scan and only save the id of the HRM with the best signal strength in the list of scanned devices. Note: command will fail with 'operation failed' if no HRM could be found during the scan or if the list of paired HRMs is full.

Table 11 Request parameter for OpCode 0x0D (scan for list of available BLE HRMs).

3.2.1.7 Control Point BLE HRM Procedure (OpCode 0x0F)

The response for OpCode 0x0F, procedure to get the Bluetooth local name of the scanned BLE HRM at position *i*, is defined in Table 12.

	Bluetooth Local Name
Octet Order	LSO...MSO
Data type	ASCII
Size	0 to 17[2] octets
Details	The Bluetooth name of the heart rate monitor, truncated at 17 characters.

Table 12 Response parameter for OpCode 0x0F.

3.2.1.8 Control Point BLE HRM Procedure (OpCode 0x10)

The response for OpCode 0x10, procedure to get the MAC address of the scanned BLE HRM at position *i*, is defined in Table 13.

	BLE id
Octet Order	LSO...MSO
Data type	N/A
Size	6 octets
Details	The full Bluetooth Address (6 bytes) of the heart Rate Monitor. LS0 MS0 6 Bytes

Table 13 Response parameter for OpCode 0x10.

3.2.1.9 Control Point BLE HRM Procedure (OpCode 0x12)

The response for OpCode 0x10, procedure to get the MAC address and state of the paired BLE HRM at position *i*, is defined in Table 14.

	LSO	MSO
	State	BLE id
Octet Order	N/A	LSO...MSO
Data type	N/A	N/A
Size	1 Octet	6 Octets
Details	Bit 0-1: Bit set to 00 – HRM state is “disconnected” Bit set to 01 – HRM state is “connected”	The full Bluetooth Address (6 bytes) of the heart Rate Monitor. LS0 MS0 6 Bytes

Table 14 Response parameter for OpCode 0x12.

3.2.1.10 CoreTemp Control Point Procedure Complete

When any of the procedures described in 3.2.1 have been executed by the server or if the procedure generated an error as defined below in this section, the server shall indicate the Core Control Point characteristic to the client. The format of the indication is defined in Table 15. The Client should implement appropriate logic to not send

[2] This is because the characteristic response should fit in a PDU smaller or equal MTU size (20 bytes).

another command until the result of the last command has not been indicated.

	LSO			MSO
	Response OpCode (0x80)	Parameter Value		
		Request OpCode	Result Code	Response Parameter (if present)
Octet Order	N/A	N/A	N/A	LSO…MSO
Data type	UINT8	UINT8	UINT8	various
Size	1 octet	1 octet	1 octet	0 to 17[3] octets

Table 15 Format of the response indication for the Core Control Point characteristic.

Table 16 defines the result code for the Core Control Point characteristic.

Result Code	Definition	Request Op Code	Response Parameter
0x00	*Reserved for future use (RFU)*	N/A	N/A
0x01	Success	All Op Codes defined in Table 6	various
0x02	Op Code not supported	All codes defined in Table 6 as reserved for future use, or all Op Codes that are not supported by the server.	None
0x03	Invalid Parameter	All Op Codes defined in Table 6	None
0x04	Operation Failed	All Op codes defined in Table 6	None

Table 16 Result Codes for Core Control Point characteristic.

If an Op Code is written to the CoreTemp Control Point that results in a successful operation, the Server shall indicate the CoreTemp Control Point with the Response Code Op Code, the Request Op Code, and the Result Code set to “Success”.

If the ‘add HRM’ Op Code is written to the CoreTemp Control Point that results in an error condition (e.g., the peripheral’s buffer for HRM’s is already full), the Server, after sending a Write Response, shall indicate the CoreTemp Control Point with the Response Code Op Code, the Request Op Code, and the Result Code set to “Operation Failed”.

If an Op Code is written to the CoreTemp Control Point characteristic that is unsupported by the Server (e.g., an Op Code that is Reserved for Future Use), the Server, after sending a Write Response, shall indicate the CoreTemp Control Point with a Response Code Op Code, the Request Op Code, and Result Code set to “Op Code Not Supported”.

If a Parameter is written to the CoreTemp Control Point characteristic that is invalid (e.g., the Client writes the ‘Get ID of HRM at index *i* Op Code with an index that is out of range) the Server, after sending a Write Response, shall indicate the CoreTemp Control Point with a Response Code Op Code, the Request Op Code, and Result Code set to “Invalid Parameter”.

If the operation results in an error condition that cannot be reported to the Client using the CoreTemp Control Point (e.g., the CoreTemp Control Point cannot be indicated), see Section 3.2.1.1 for details on handling this condition.

[3] This is because the characteristic response should fit in a PDU smaller or equal MTU size (20 bytes).

4 Glossary

Term	Requirement
BLE	Bluetooth Low Energy
LSO	Least significant octet
HRM	Heart Rate Monitor
MSO	Most significant octet
RFU	Reserved for future use.
UUID	Universally Unique Identifier
Server	*Also:* The Peripheral. In the context of this Specification: The CoreTemp device that sends data to the Client.
Client	*Also:* The Central. In the context of this Specification: The display device such as mobile phone app or a smartwatch.

5 References

[1] Supplement to the Bluetooth Core Specification, v10 or later

Appendix A: Complementary Services

1. Health Thermometer Service

The core body temperature sensor may optionally implement the health thermometer service (16bit UUID: 0x1809) to make the temperature readings available for clients adopting only the standardized BLE service.

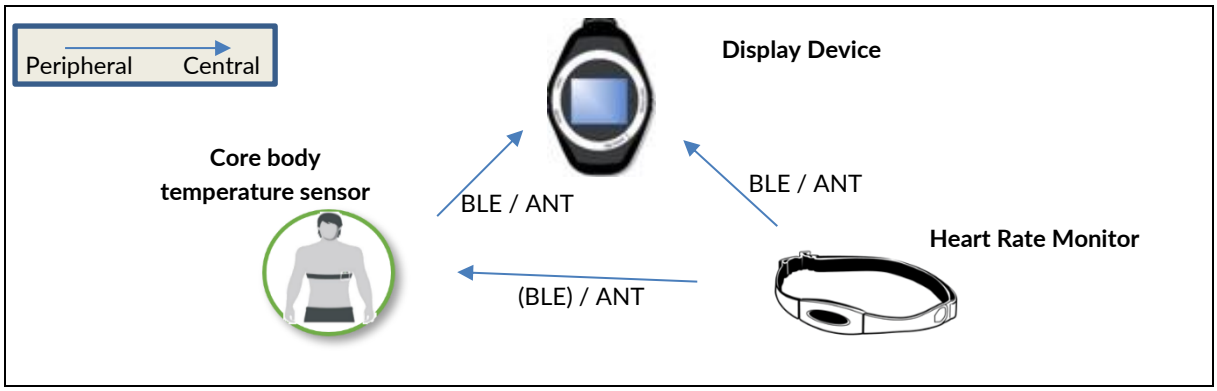
2. Device Information Service

The core body temperature sensor may optionally implement the Device Information service (16bit UUID: 0x180A) to be compliant with the Health Thermometer Profile.

3. Battery Service

The core body temperature sensor may optionally implement the battery service (16bit UUID: 0x180F) as a complementary service.

Appendix B: Scenarios Heart Rate Pairing



Scenario 1	Display device wants to get a **list of the paired HRMs** • Display device sends OpCode 0x04 to get total number of paired HRMs • Then, it sends OpCode 0x05 with payload index *i*, for all *i* in range(0, total number of HRMs) • From the response to this command, the Display Device can tell which HRMs are paired with the core body temperature sensor and whether they are currently connected to the core body temperature sensor.
Scenario 2	Assume the Peripheral Phone app wants to **change the list** of Heart Rate Monitors the Peripheral should listen to = try to establish a connection to receive a heart rate signal • Central will get the list of currently "paired" heart rate monitors = list of HRM devices as described in *Scenario 1*. • Central will then send command to add / remove / remove all HRM devices from the Peripheral. • Note: Peripheral will then attempt to connect to one of the HRMs, cycling through the list.