

BLUETOOTH® DOC	Date / Year-Month-Day 2013-04-30	Approved Adopted	Revision V10	Document No CPS_SPEC
Prepared By SF WG	E-mail Address sf-main@bluetooth.org			N.B.

CYCLING POWER SERVICE

Abstract:

This service exposes power- and force-related data and optionally speed- and cadence-related data from a Cycling Power sensor intended for sports and fitness applications.

Revision History

Revision	Date (yyyy-mm-dd)	Comments
D09r00	2012-09-27	Initial Draft, based on Cycling Speed and Cadence Service.
D09r10	2013-01-25	Version approved by BARB and used at formal IOP.
V10	2013-04-30	Adopted by the Bluetooth SIG Board of Directors

Contributors

Name	Company
Robert Hughes	Intel Corporation
Jari Miettinen	Polar
Niclas Granqvist	Polar
Guillaume Schatz	Polar
Ed Watson	Saris

Disclaimer and Copyright Notice

The copyright in this specification is owned by the Promoter Members of Bluetooth® Special Interest Group (SIG), Inc. ("Bluetooth SIG"). Use of these specifications and any related intellectual property (collectively, the "Specification"), is governed by the Promoters Membership Agreement among the Promoter Members and Bluetooth SIG (the "Promoters Agreement"), certain membership agreements between Bluetooth SIG and its Adopter and Associate Members (the "Membership Agreements") and the Bluetooth Specification Early Adopters Agreements (1.2 Early Adopters Agreements) among Early Adopter members of the unincorporated Bluetooth SIG and the Promoter Members (the "Early Adopters Agreement"). Certain rights and obligations of the Promoter Members under the Early Adopters Agreements have been assigned to Bluetooth SIG by the Promoter Members.

Use of the Specification by anyone who is not a member of Bluetooth SIG or a party to an Early Adopters Agreement (each such person or party, a "Member") is prohibited. The legal rights and obligations of each Member are governed by their applicable Membership Agreement, Early Adopters Agreement or Promoters Agreement. No license, express or implied, by estoppel or otherwise, to any intellectual property rights are granted herein.

Any use of the Specification not in compliance with the terms of the applicable Membership Agreement, Early Adopters Agreement or Promoters Agreement is prohibited and any such prohibited use may result in termination of the applicable Membership Agreement or Early Adopters Agreement and other liability permitted by the applicable agreement or by applicable law to Bluetooth SIG or any of its members for patent, copyright and/or trademark infringement.

THE SPECIFICATION IS PROVIDED "AS IS" WITH NO WARRANTIES WHATSOEVER, INCLUDING ANY WARRANTY OF MERCHANTABILITY, NONINFRINGEMENT, FITNESS FOR ANY PARTICULAR PURPOSE, SATISFACTORY QUALITY, OR REASONABLE SKILL OR CARE, OR ANY WARRANTY ARISING OUT OF ANY COURSE OF DEALING, USAGE, TRADE PRACTICE, PROPOSAL, SPECIFICATION OR SAMPLE.

Each Member hereby acknowledges that products equipped with the *Bluetooth* technology ("*Bluetooth* products") may be subject to various regulatory controls under the laws and regulations of various governments worldwide. Such laws and regulatory controls may govern, among other things, the combination, operation, use, implementation and distribution of *Bluetooth* products. Examples of such laws and regulatory controls include, but are not limited to, airline regulatory controls, telecommunications regulations, technology transfer controls and health and safety regulations. Each Member is solely responsible for the compliance by their Bluetooth Products with any such laws and regulations and for obtaining any and all required authorizations, permits, or licenses for their Bluetooth products related to such regulations within the applicable jurisdictions. Each Member acknowledges that nothing in the Specification provides any information or assistance in connection with securing such compliance, authorizations or licenses. **NOTHING IN THE SPECIFICATION CREATES ANY WARRANTIES, EITHER EXPRESS OR IMPLIED, REGARDING SUCH LAWS OR REGULATIONS.**

ALL LIABILITY, INCLUDING LIABILITY FOR INFRINGEMENT OF ANY INTELLECTUAL PROPERTY RIGHTS OR FOR NONCOMPLIANCE WITH LAWS, RELATING TO USE OF THE SPECIFICATION IS EXPRESSLY DISCLAIMED. BY USE OF THE SPECIFICATION, EACH MEMBER EXPRESSLY WAIVES ANY CLAIM AGAINST BLUETOOTH SIG AND ITS PROMOTER MEMBERS RELATED TO USE OF THE SPECIFICATION.

Bluetooth SIG reserve the right to adopt any changes or alterations to the Specification as it deems necessary or appropriate.

Copyright © 2013. Bluetooth® SIG, Inc. All copyrights in the Bluetooth Specifications themselves are owned by Ericsson AB, Lenovo (Singapore) Pte. Ltd., Intel Corporation, Microsoft Corporation, Motorola Mobility LLC, Nokia Corporation, and Toshiba Corporation.

***Other third-party brands and names are the property of their respective owners.**

Document Terminology

The Bluetooth SIG has adopted Section 13.1 of the IEEE Standards Style Manual, which dictates use of the words “shall”, “should”, “may”, and “can” in the development of documentation, as follows:

The word *shall* is used to indicate mandatory requirements strictly to be followed in order to conform to the standard and from which no deviation is permitted (*shall* equals *is required to*).

The use of the word *must* is deprecated and shall not be used when stating mandatory requirements; *must* is used only to describe unavoidable situations.

The use of the word *will* is deprecated and shall not be used when stating mandatory requirements; *will* is only used in statements of fact.

The word *should* is used to indicate that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required; or that (in the negative form) a certain course of action is deprecated but not prohibited (*should* equals *is recommended that*).

The word *may* is used to indicate a course of action permissible within the limits of the standard (*may* equals *is permitted*).

The word *can* is used for statements of possibility and capability, whether material, physical, or causal (*can* equals *is able to*).

The term *Reserved for Future Use (RFU)* is used to indicate Bluetooth SIG assigned values that are reserved by the Bluetooth SIG and are not otherwise available for use by implementations.

Table of Contents

1	Introduction	7
1.1	Conformance	7
1.2	Service Dependency	7
1.3	Bluetooth Specification Release Compatibility	7
1.4	GATT Sub-Procedure Requirements	7
1.5	Transport Dependencies	7
1.6	Error Codes	8
1.7	Byte Transmission Order	8
2	Service Declaration	9
3	Service Characteristics	10
3.1	Cycling Power Feature	10
3.1.1	Characteristic Behavior	10
3.2	Cycling Power Measurement	11
3.2.1	Characteristic Behavior	11
3.2.1.1	Flags Field	12
3.2.1.2	Instantaneous Power Field	13
3.2.1.3	Pedal Power Balance Field	13
3.2.1.4	Accumulated Torque Field	13
3.2.1.5	Wheel Revolution Data Field Pair	13
3.2.1.6	Crank Revolutions Data Field Pair	14
3.2.1.7	Extreme Force Magnitudes Field Pair	15
3.2.1.8	Extreme Torque Magnitudes Field Pair	15
3.2.1.9	Extreme Angles Field Pair	15
3.2.1.10	Top Dead Spot Angle Field	15
3.2.1.11	Bottom Dead Spot Angle Field	16
3.2.1.12	Accumulated Energy Field	16
3.2.1.13	Cycling Power Measurement Broadcast Feature	16
3.3	Sensor Location	16
3.3.1	Characteristic Behavior	17
3.4	Cycling Power Control Point	17
3.4.1	Cycling Power Control Point Procedure Requirements	17
3.4.2	Cycling Power Control Point Behavioral Description	19
3.4.2.1	Set Cumulative Value Procedure	19
3.4.2.2	Update Sensor Location Procedure	20
3.4.2.3	Request Supported Sensor Locations Procedure	20
3.4.2.4	Set Crank Length Procedure	21
3.4.2.5	Request Crank Length Procedure	21
3.4.2.6	Set Chain Length Procedure	21
3.4.2.7	Request Chain Length Procedure	22
3.4.2.8	Set Chain Weight Procedure	22
3.4.2.9	Request Chain Weight Procedure	22
3.4.2.10	Set Span Length Procedure	23
3.4.2.11	Request Span Length Procedure	23
3.4.2.12	Start Offset Compensation Procedure	23
3.4.2.13	Mask Cycling Power Measurement Characteristic Content	24
3.4.2.14	Request Sampling Rate Procedure	25
3.4.2.15	Request Factory Calibration Date Procedure	25
3.4.3	General Error Handling procedures	25
3.4.4	Procedure Timeout	26
3.5	Cycling Power Vector	26
3.5.1	Characteristic Behavior	27
3.5.1.1	Flags Field	27
3.5.1.2	Crank Revolution Data Field Pair	28

Cycling Power Service

	3.5.1.3 First Crank Measurement Angle Field	29
	3.5.1.4 Instantaneous Force Magnitude Array Field	29
	3.5.1.5 Instantaneous Torque Magnitude Array Field	30
3.6	Requirements for Time-Sensitive Data	31
3.7	Requirements for Servers Used for a Distributed Power System	31
4	SDP Interoperability	32
5	Acronyms and Abbreviations	33
6	References	34

1 Introduction

The Cycling Power (CP) Service exposes power- and force-related data and optionally speed- and cadence-related data from a Cycling Power sensor (Server) intended for sports and fitness applications.

1.1 Conformance

If a device claims conformance to this service, all capabilities indicated as mandatory for this service shall be supported in the specified manner (process-mandatory). This also applies for all optional and conditional capabilities for which support is indicated. All mandatory capabilities, and optional and conditional capabilities for which support is indicated, are subject to verification as part of the Bluetooth qualification program.

1.2 Service Dependency

This service is not dependent upon any other services.

1.3 Bluetooth Specification Release Compatibility

This specification is compatible with any of the following:

- Bluetooth Core Specification 4.0 with CSA2, CSA3 and CSA4 [1]
- A Bluetooth Core Specification later than 4.0.

1.4 GATT Sub-Procedure Requirements

Requirements in this section represent a minimum set of requirements for a Server. Other GATT sub-procedures may be used if supported by both Client and Server.

Table 1.1 summarizes additional GATT sub-procedure requirements beyond those required by all GATT Servers.

GATT Sub-Procedure	Requirements
Write Characteristic Value	C.1
Notifications	M
Indications	C.1
Read Characteristic Descriptors	M
Write Characteristic Descriptors	M

Table 1.1: GATT Sub-procedure Requirements

C.1: Mandatory if the Cycling Power Control Point characteristic is supported, otherwise excluded for this service.

1.5 Transport Dependencies

With the exception of the Cycling Power Measurement Broadcast feature (see Section 3.2.1.13) used in an advanced mode of operation, there are no transport restrictions imposed by this service specification. In that case, the LE method of broadcasting is used and broadcasting over BR/EDR is not supported.

Cycling Power Service

Where the term BR/EDR is used throughout this document, this also includes the use of AMP.

1.6 Error Codes

This service defines the following Attribute Protocol Application Error code:

Name	Error Code	Description
Inappropriate Connection Parameters	0x80	The notifications of the Cycling Power Vector characteristic cannot be sent due to inappropriate connection parameters.

Table 1.2: Application Error Codes

1.7 Byte Transmission Order

All characteristics used with this service shall be transmitted with the least significant octet first (i.e., little endian). The least significant octet is identified in the characteristic definitions in [\[2\]](#).

2 Service Declaration

The Cycling Power Service should be instantiated as a «Primary Service».

The service UUID shall be set to «Cycling Power Service» defined in [\[2\]](#).

3 Service Characteristics

The following characteristics are exposed in the Cycling Power Service. Only one instance of each characteristic is permitted within this service. The characteristic formats and UUIDs are defined in [2].

Where a characteristic can be notified or indicated, a Client Characteristic Configuration descriptor shall be included in that characteristic as required by the Core Specification [1].

Where a characteristic can be broadcasted, a Server Characteristic Configuration descriptor shall be included in that characteristic as required by the Core Specification [1].

Characteristic Name	Requirement	Mandatory Properties	Optional Properties	Security Permissions
Cycling Power Feature	M	Read		None.
Cycling Power Measurement	M	Notify	LE: Broadcast BR/EDR: None	None.
Sensor Location	M	Read		None.
Cycling Power Control Point	O	Write, Indicate		None.
Cycling Power Vector	O	Notify		None

Table 3.1: Cycling Power Service characteristics

Notes:

- Security Permissions of “None” means that this service does not impose any requirements.
- Properties not listed as Mandatory or Optional are Excluded for this version of this service.

3.1 Cycling Power Feature

The Cycling Power Feature characteristic shall be used to describe the supported features of the Server.

Reserved for Future Use (RFU) bits in the Cycling Power Feature characteristic value shall be set to 0.

3.1.1 Characteristic Behavior

When read, the Cycling Power Feature characteristic returns a value that is used by a Client to determine the supported features of the Server.

The bits of the Cycling Power Feature characteristic may either be static for the lifetime of the device (i.e., static permanently or until Service Changed is indicated) or guaranteed to be static only during a connection. Although all defined bits (i.e., bits 0 to 18) in this version of this specification are required to be static during the lifetime of a device, it is possible that some future bits will be defined as being static only during a connection.

When the Server supports a feature, the associated bit of the Cycling Power Feature characteristic shall be set to 1 (Feature supported), otherwise, the associated bit shall be set to 0 (Feature not supported). The feature bits are defined in [2].

3.2 Cycling Power Measurement

The Cycling Power Measurement characteristic is used to send power-related data, speed-related data, and/or cadence-related data. Included in the characteristic value are a Flags field (for showing the presence of optional fields and measurement status), an Instantaneous Power field and depending upon the contents of the Flags field, may include one or more optional fields defined in [2].

3.2.1 Characteristic Behavior

When the Cycling Power Measurement characteristic is configured for notification via the *Client Characteristic Configuration* descriptor and a power-related measurement is available, this characteristic shall be notified. The Server should notify this characteristic at a regular interval, typically once per second while in a connection and is not configurable by the Client.

If the Cycling Power Measurement Broadcast feature is supported by the LE Server (see Section 3.2.1.13) and when the Cycling Power Measurement characteristic is configured for broadcast via the *Server Characteristic Configuration* descriptor and a power-related measurement is available, this characteristic shall be broadcasted (e.g., non-connectable undirected advertisement events) while in a connection (e.g. the Server stops broadcasting when disconnected). The Server should broadcast this characteristic at a regular interval. This should be typically broadcasted at the same interval as the notification of this characteristic.

For an LE Server that supports the Cycling Power Measurement Broadcast feature, it shall support the sending of notifications and broadcasts while in a connection.

If the Server supports the Cycling Power Measurement Characteristic Content Masking feature and if the Client does not need a particular field of the Cycling Power Measurement characteristic, the Server may allow the Client to turn off that particular field of the Cycling Power Measurement characteristic as described in Section 3.4.2.13. When a Client turns off some fields of the Cycling Power Measurement characteristic, this may affect the broadcast of the Cycling Power Measurement characteristic as described in Section 3.2.1.13 and is left to the implementation.

Refer to Section 3.7 for additional recommendations for distributed power sensor systems (e.g., one CP Sensor on each pedal measuring the left and right power contribution).

For LE, all the fields of this characteristic cannot be present simultaneously if using a default MTU size. For notification, if the characteristic size exceeds the current MTU size, the remaining optional fields shall be sent in the subsequent notification. Refer to Section 3.2.1.13 for additional requirements on the Cycling Power Measurement Broadcast feature.

For BR/EDR, this restriction does not exist due to a larger MTU size.

Cycling Power Service

The Cycling Power Measurement characteristic contains time-sensitive data, thus the requirements for time-sensitive data and data storage defined in Section 3.6 apply.

3.2.1.1 Flags Field

The Flags field shall be included in the Cycling Power Measurement characteristic.

Reserved for Future Use (RFU) bits in the Flags fields shall be set to 0.

The bits of the Flags field, their function, and relationship to bits in the Cycling Power Feature characteristic are shown in Table 3.2.

Flags Bit Name	When Set to 0	When Set to 1	Corresponding Cycling Power Feature support bit (see Section 3.1)
Pedal Power Balance Present (bit 0), see 3.2.1.3	Corresponding field not present	Corresponding field present	Pedal Power Balance Supported (bit 0)
Pedal Power Balance Reference (bit 1), see Note 1 and 3.2.1.3	Unknown	Left	Pedal Power Balance Supported (bit 0)
Accumulated Torque Present (bit 2), see 3.2.1.4	Corresponding field not present	Corresponding field present	Accumulated Torque Supported (bit 1)
Accumulated Torque Source (bit 3), see Note 1 and 3.2.1.4	Wheel Based	Crank Based	Accumulated Torque Supported (bit 1)
Wheel Revolution Data Present (bit 4), see 3.2.1.5	Corresponding field pair not present	Corresponding field pair present	Wheel Revolution Data Supported (bit 2)
Crank Revolution Data Present (bit 5), see 3.2.1.6	Corresponding field pair not present	Corresponding field pair present	Crank Revolution Data Supported (bit 3)
Extreme Force Magnitudes Present (bit 6), see 3.2.1.7	Corresponding field pair not present	Corresponding field pair present	Extreme Magnitudes Supported (bit 4) and Sensor Measurement Context set to Force-based (bit 16)
Extreme Torque Magnitudes Present (bit 7), see 3.2.1.8	Corresponding field pair not present	Corresponding field pair present	Extreme Magnitudes Supported (bit 4) and Sensor Measurement Context set to Torque-based (bit 16)
Extreme Angles Present (bit 8), see 3.2.1.9	Corresponding field pair not present	Corresponding field pair present	Extreme Angles Supported (bit 5)
Top Dead Spot Angle Present (bit 9), see 3.2.1.10	Corresponding field not present	Corresponding field present	Top and Bottom Dead Spot Angles Supported (bit 6)
Bottom Dead Spot Angle Present (bit 10), see 3.2.1.11	Corresponding field not present	Corresponding field present	Top and Bottom Dead Spot Angles Supported (bit 6)
Accumulated Energy Present (bit 11), see 3.2.1.12	Corresponding field not present	Corresponding field present	Accumulated Energy Supported (bit 7)
Offset Compensation Indicator (bit 12), see Note 1 and 3.4.2.12	No required action	Offset compensation action required	Offset Compensation Indicator Supported (bit 8)

Table 3.2: Bit Definitions for the Cycling Power Measurement Characteristic

Note 1: If the corresponding feature bit of the Cycling Power Feature characteristic is set to 0, then this bit has no meaning and shall be set to 0.

Each of the Flags bits in the table above may change during a connection if the corresponding support bit in the Cycling Power Feature characteristic is set to 1 indicating that the feature is supported. If the corresponding support bit is however set to 0, then the corresponding Flags bit shall also be set to 0 since the feature is not supported.

3.2.1.2 Instantaneous Power Field

The Instantaneous Power field shall be included in the Cycling Power Measurement characteristic.

The Instantaneous Power field represents the value of the power measured by the Server. It represents either the total power the user is producing or a part of the total power depending on the type of sensor (e.g., single sensor or distributed power sensor system). Refer to Section 3.7 for additional requirements for distributed power sensor systems (e.g., one CP Sensor on each pedal measuring the left and right power contribution).

3.2.1.3 Pedal Power Balance Field

The Pedal Power Balance field may be included in the Cycling Power Measurement characteristic if the Server supports the Pedal Power Balance feature (see Table 3.2).

The Pedal Power Balance field represents the ratio between the total amount of power measured by the sensor and a reference (either unknown or left). For example, if the sensor provides the power balance referenced to the left pedal, the power balance is calculated as $[\text{LeftPower}/(\text{LeftPower} + \text{RightPower})]*100$ in units of percent.

When supported, the Pedal Power Balance Reference bit of the Flags field (bit 1) describes whether the value is referenced from 'left' or the reference is 'unknown'.

3.2.1.4 Accumulated Torque Field

The Accumulated Torque field may be included in the Cycling Power Measurement characteristic if the device supports the Accumulated Torque feature (see Table 3.2).

The Accumulated Torque field represents the cumulative value of the torque measured by the Sensor. When a connection is established, this value starts at 0 Newton meter and is may roll over.

When supported, the Accumulated Torque Source bit of the Flags field (bit 3) describes whether the value is 'wheel based' or 'crank based'.

The Accumulated Torque value may decrease.

3.2.1.5 Wheel Revolution Data Field Pair

The Wheel Revolution Data field pair (Cumulative Wheel Revolutions and Last Wheel Event Time fields) may be included in the Cycling Power Measurement characteristic if the device supports the Wheel Revolution Data feature (see Table 3.2). When present, these fields shall always be present as a pair.

The Cumulative Wheel Revolution value is not permitted to roll over.

The Cumulative Wheel Revolutions value, which represents the number of times a wheel rotates, is used in combination with the Last Wheel Event Time and the wheel circumference value available on the collector device to enable it to calculate 1) the speed of the bicycle, 2) the distance traveled and 3) and the power if combined with the Crank Revolution Data. In addition, if there is link loss, the Cumulative Wheel Revolutions value can be used to calculate the average speed of the bicycle during the link loss. This value is expected to be set to 0 (or another desired value in case of e.g., a sensor upgrade) at initial installation on a bicycle as described in Section 3.4.2.1. The Cumulative Wheel Revolutions value may decrement for some implementations (e.g., if the bicycle is rolled in reverse), but shall not decrease below 0.

The 'wheel event time' is a free-running-count of 1/2048 second units and it represents the time when the wheel revolution was detected by the wheel rotation sensor. Since several wheel events can occur between transmissions, only the Last Wheel Event Time value is transmitted.

See Section 3.4.2.1 for requirements related to setting the value of the Cumulative Wheel Revolutions field.

The Last Wheel Event Time value rolls over every 32 seconds.

3.2.1.6 Crank Revolutions Data Field Pair

The Crank Revolution Data field pair (Cumulative Crank Revolutions and Last Crank Event Time fields) may be included in the Cycling Power Measurement characteristic if the device supports the Crank Revolution Data feature (see Table 3.2). When present, these fields shall always be present as a pair.

The Cumulative Crank Revolutions value, which represents the number of times a crank rotates, is used in combination with the Last Crank Event Time to enable the Client to

- 1) Determine if the cyclist is coasting and
- 2) Calculate the instantaneous and average cadence
- 3) Calculate the power if combined with the Wheel Revolution Data

Average cadence is not accurate unless 0 cadence events (i.e., coasting) are subtracted. In addition, if there is link loss, the Cumulative Crank Revolutions value can be used to calculate the average cadence during the link loss. This value is intended to roll over and is not configurable.

The 'crank event time' is a free-running-count of 1/1024 second units and it represents the time when the crank revolution was detected by the crank rotation sensor. Since several crank events can occur between transmissions, only the Last Crank Event Time value is transmitted.

The Last Crank Event Time value rolls over every 64 seconds.

To enhance the user experience, the Server should ignore the extra crank revolutions that may be detected when the user is not pedaling (e.g., coasting down the hill) but the sensor is facing the crank revolution detection system (e.g., a magnet installed on the crankset) and may cause unwanted crank revolution detections.

3.2.1.7 Extreme Force Magnitudes Field Pair

The Extreme Force Magnitude field pair (Maximum Force Magnitude and Minimum Force Magnitude fields) may be included in the Cycling Power Measurement characteristic if the device supports the Extreme Magnitudes feature and the Sensor Measurement Context of the Cycling Power Feature characteristic is set to 0 (Force-based). Otherwise, this field pair is excluded from this characteristic (see [Table 3.2](#)). When present, these fields shall always be present as a pair.

The Maximum Force Magnitude field represents the maximum force value measured in a single crank revolution; respectively the Minimum Force Magnitude field represents the minimum force value measured in a single crank revolution.

Since a Server supports only one measurement context (e.g., Force-based or Torque-based), the support of these fields excludes the support of the Maximum Torque Magnitude and Minimum Torque Magnitude fields.

3.2.1.8 Extreme Torque Magnitudes Field Pair

The Extreme Torque Magnitudes field pair (Maximum Torque Magnitude and Minimum Torque Magnitude fields) may be included in the Cycling Power Measurement characteristic if the device supports the Extreme Magnitudes feature and the Sensor Measurement Context of the Cycling Power Feature characteristic is set to 1 (Torque-based). Otherwise, this field pair is excluded from this characteristic (see [Table 3.2](#)). When present, these fields shall always be present as a pair.

The Maximum Torque Magnitude field represents the maximum torque value measured in a single crank revolution; respectively the Minimum Torque Magnitude field represents the minimum torque value measured in a single crank revolution.

Since a Server supports only one measurement context (e.g., Force-based or Torque-based), the support of these fields excludes the support of the Maximum Force Magnitude and Minimum Force Magnitude fields.

3.2.1.9 Extreme Angles Field Pair

The Extreme Angles field pair (Maximum Angle and Minimum Angle fields) may be included in the Cycling Power Measurement characteristic if the device supports the Extreme Angles feature (see [Table 3.2](#)). When present, these fields shall always be present as a pair.

The Maximum Angle field represents the angle of the crank when the maximum value is measured in a single crank revolution. Similarly the Minimum Angle field represents the angle of the crank when the minimum value is measured in the same crank revolution. The maximum and minimum values measured in a single crank revolution refer to either Maximum Force Magnitude and Minimum Force Magnitude field pairs or Maximum Torque Magnitude and Minimum Torque Magnitude field pairs.

3.2.1.10 Top Dead Spot Angle Field

The Top Dead Spot Angle field may be included in the Cycling Power Measurement characteristic if the device supports the Top and Bottom Dead Spot Angles feature (see [Table 3.2](#)).

The Top Dead Spot Angle field represents the crank angle when the value of the Instantaneous Power value becomes positive.

3.2.1.11 Bottom Dead Spot Angle Field

The Bottom Dead Spot Angle field may be included in the Cycling Power Measurement characteristic if the device supports the Top and Bottom Dead Spot Angles feature (see [Table 3.2](#)).

The Bottom Dead Spot Angle field represents the crank angle when the value of the Instantaneous Power value becomes negative.

3.2.1.12 Accumulated Energy Field

The Accumulated Energy field may be included in the Cycling Power Measurement characteristic if the device supports the Accumulated Energy feature (see [Table 3.2](#)).

The Accumulated Energy field represents the accumulated value of the energy measured by the sensor. When a connection is established, this value starts at 0 kilo Joules and is not expected to roll over.

3.2.1.13 Cycling Power Measurement Broadcast Feature

The Cycling Power Measurement Broadcast feature is optional when using the LE transport and it is not applicable to BR/EDR.

When the Cycling Power Measurement Broadcast is enabled by the Client (e.g., via the *Server Characteristic Configuration* descriptor), the Server shall send the Cycling Power Measurement characteristic value in a non-connectable undirected advertising event. The Advertising Data shall not exceed 31 octets and shall include the AD Structure Data described in [Table 3.3](#):

AD Type	AD Data
Advertising Interval	advInterval value
Service Data	Cycling Power Service UUID followed by the Cycling Power Measurement characteristic value

Table 3.3: Broadcast AD Structures Requirements

When the Cycling Power Measurement Broadcast is disabled by the Client (e.g., via the *Server Characteristic Configuration* descriptor), the Server shall stop advertising. The Server shall also stop advertising when disconnected from the Client.

The Server may elect to send different fields of the Cycling Power Measurement characteristic when broadcasting (non-connectable undirected advertisement) as when notifying. Typically, the fields included in the broadcast are the mandatory fields (i.e., the Flags field and the Instantaneous Power field) and the Crank Revolution Data field (i.e., the Cumulative Crank Revolutions and the Last Crank Event Time field pair).

3.3 Sensor Location

The Sensor Location characteristic of the device may be used to describe the physical location of the Server when correctly fitted.

Cycling Power Service

If the Server supports the Multiple Sensor Locations feature, the value of the Sensor Location characteristic may be updated while in a connection as described in Section 3.4.2.2. Otherwise, if the Sensor Location characteristic is present and the Multiple Sensor Locations feature is not supported, the value of the Sensor Location shall be static for the lifetime of the Server or until Service Changed characteristic is indicated.

If the Server supports the Multiple Sensor Locations feature, the Client should not assume that the value of the Sensor Location characteristic of the Server is set to the same value as at the end of a previous connection. This is primarily because the value may have been altered by a different Client after the previous connection (e.g., the user has moved his sensor to another location and configured the new Sensor Location with another Client).

Refer to Section 3.7 for additional recommendations for distributed power sensor systems (e.g., one CP Sensor on each pedal measuring the left and right power contribution).

3.3.1 Characteristic Behavior

The Sensor Location characteristic returns the sensor location value when read.

3.4 Cycling Power Control Point

If the Cycling Power Control Point is supported, profiles utilizing this service are required to ensure that the Client configures the Cycling Power Control Point characteristic for indications (i.e., via the *Client Characteristic Configuration* descriptor) at the first connection.

Support for this characteristic is mandatory if the Server supports Wheel Revolution Data or Multiple Sensor Locations features, or if settings are configurable or if the Server allows a Client to do offset compensation or if the Server allows a Client to request some parameters; otherwise, it is excluded for this version of the service in accordance with Table 3.1.

Refer to Section 3.7 for additional recommendations for distributed power sensor systems (e.g., one CP Sensor on each pedal measuring the left and right power contribution).

3.4.1 Cycling Power Control Point Procedure Requirements

Table 3.4 shows the requirements for the Cycling Power Control Point characteristic in the context of this service.

A Client shall use the *Write Characteristic Value* procedure to initiate a procedure defined in the Table 3.4.

Cycling Power Service

Procedure	Requirement	Parameter Description	Applicable Response Value	Response Parameter
Set Cumulative Value	C.1	Cumulative Value	Success, Operation Failed, Invalid Parameter, Op Code Not Supported	None
Update Sensor Location	C.2	Sensor Location	Success, Operation Failed, Invalid Parameter, Op Code Not Supported	None
Request Supported Sensor Locations	C.2	None	Success	Byte array – see 3.4.2.3
			Operation Failed, Op Code Not, Supported	None
Set Crank Length	C.3	Crank Length	Success, Operation Failed, Invalid Parameter, Op Code Not Supported	None
Request Crank Length	C.4	None	Success	Crank Length
			Operation Failed, Op Code Not Supported	None
Set Chain Length	C.5	Chain Length	Success, Operation Failed, Invalid Parameter, Op Code Not Supported	None
Request Chain Length	C.6	None	Success	Chain Length
			Operation Failed, Op Code Not Supported	None
Set Chain Weight	C.7	Chain Weight	Success, Operation Failed, Invalid Parameter, Op Code Not Supported	None
Request Chain Weight	C.8	None	Success	Chain Weight
			Operation Failed, Op Code Not Supported	None
Set Span Length	C.9	Span Length	Success, Operation Failed, Invalid Parameter, Op Code Not Supported	None
Request Span Length	C.10	None	Success	Span Length
			Operation Failed, Op Code Not Supported	None
Start Offset Compensation	C.11	None	Success	Raw Data
			Operation Failed, Invalid Parameter, Op Code Not Supported	None
Mask Cycling Power Measurement Characteristic Content	C.12	Content Mask	Success, Operation Failed, Invalid Parameter, Op Code Not Supported	None
Request Sampling Rate	C.13	None	Success	Sampling Rate
			Operation Failed, Op Code Not Supported	None

Cycling Power Service

Procedure	Requirement	Parameter Description	Applicable Response Value	Response Parameter
Request Factory Calibration Date	C.14	None	Success	Factory Calibration Date
			Operation Failed, Op Code Not Supported	None

Table 3.4: Cycling Power Control Point Procedure Requirements

- C.1: Mandatory if Wheel Revolutions Data feature is supported, otherwise excluded from this version of this Service.
- C.2: Mandatory if Multiple Sensor Locations feature is supported, otherwise excluded from this version of this Service.
- C.3: Mandatory if the Crank Length Adjustment feature is supported, otherwise excluded from this version of this Service.
- C.4: Mandatory if the Crank Length Adjustment feature is supported, otherwise optional.
- C.5: Mandatory if the Chain Length Adjustment feature is supported, otherwise excluded from this version of this Service.
- C.6: Mandatory if the Chain Length Adjustment feature is supported, otherwise optional.
- C.7: Mandatory if the Chain Weight Adjustment feature is supported, otherwise excluded from this version of this Service.
- C.8: Mandatory if the Chain Weight Adjustment feature is supported, otherwise optional.
- C.9: Mandatory if the Span Length Adjustment feature is supported, otherwise excluded from this version of this Service.
- C.10: Mandatory if the Span Length Adjustment feature is supported, otherwise optional.
- C.11: Mandatory if the Offset Compensation feature is supported, otherwise excluded from this version of this Service.
- C.12: Mandatory if the Cycling Power Measurement Characteristic Content Masking feature is supported, otherwise excluded from this version of this Service.
- C.13: Mandatory if the Cycling Power Vector characteristic is supported, otherwise optional.
- C.14: Mandatory if the Factory Calibration Date feature is supported, otherwise optional.

3.4.2 Cycling Power Control Point Behavioral Description

The Cycling Power Control Point is used by a Client to control certain behaviors of the Server. Procedures are triggered by a Write to this characteristic value that includes an Op Code specifying the operation (see [Table 3.4](#)) which may be followed by a Parameter that is valid within the context of that Op Code.

3.4.2.1 Set Cumulative Value Procedure

When the *Set Cumulative Value* Op Code is written to the Cycling Power Control Point and if the Wheel Revolution Data feature is supported by the Server, the Server shall set the Cumulative Wheel Revolutions value to the desired cumulative wheel revolution value transmitted as a Parameter of the Cycling Power Control Point. The format of the Parameter Value of this Control Point is UINT32 and represents the cumulative value in number of revolutions with a resolution of 1 revolution. The response shall be indicated when the Cumulative Wheel Revolutions value is applied using the *Response Code* Op Code, the *Request* Op Code along with “Success” or other appropriate *Response Value*.

Cycling Power Service

If the operation results in an error condition, or if this Op Code is not supported by the Server, see Section 3.4.3 for details on handling this condition.

This procedure shall not be used to set the following values since they are not configurable.

- The Cumulative Crank Revolutions value of the Cycling Power Measurement characteristic or
- The Cumulative Crank Revolutions value of the Cycling Power Vector characteristic or
- The Accumulated Torque value or the Accumulated Energy of the Cycling Power Measurement characteristic.

This procedure should be used when the bicycle is not moving to avoid erroneous value of instantaneous speed, which may also impact other values calculated by the collector device (i.e., average speed, maximum speed).

3.4.2.2 Update Sensor Location Procedure

When the *Update Sensor Location* Op Code is written to the Cycling Power Control Point and if the Multiple Sensor Locations feature is supported by the Server, the Server shall update the value of the Sensor Location characteristic with the value of the desired sensor location transmitted as a Parameter Value of the Cycling Power Control Point. The format of the Parameter Value of this Control Point is UINT8 and represents the sensor location as defined in the Sensor Location characteristic [2]. For example, a parameter of 0x0D will set the sensor location to “Rear Hub”. The response shall be indicated when the sensor location is updated in the Server using the *Response Code* Op Code, the *Request* Op Code along with “Success” or other appropriate *Response Value*.

The Server should cache the most recent value of the Sensor Location characteristic to avoid reconfiguration of this characteristic by the Client each time a connection is established.

If the operation results in an error condition, or if this Op Code is not supported by the Server, see Section 3.4.3 for details on handling this condition.

This procedure should be used when the bicycle is not moving to avoid unexpected behavior.

3.4.2.3 Request Supported Sensor Locations Procedure

When the *Request Supported Sensor Locations* Op Code is written to the Cycling Power Control Point and if the Multiple Sensor Locations feature is supported by the Server, the Server shall send a list of the supported sensor location values (i.e., a byte array containing values of each supported sensor location). The response shall be indicated using the *Response Code* Op Code, the *Request* Op Code, the appropriate *Response Value* and, if the procedure succeeds, the *Response Value* shall be set to “Success” followed by a list of supported sensor location values in the Response Parameter. The format of the Response Parameter, in response to this Control Point, is a UINT8 array and represents the sensor locations the Server supports.

Cycling Power Service

For LE Transport and a default ATT MTU, a maximum of 17 supported sensor locations can be sent.

If the operation results in an error condition, or if this Op Code is not supported by the Server, see Section 3.4.3 for details on handling this condition.

3.4.2.4 Set Crank Length Procedure

When the *Set Crank Length* Op Code is written to the Cycling Power Control Point and if the Crank Length Adjustment feature is supported by the Server, the Server shall store the desired crank length transmitted as a Parameter of the Cycling Power Control Point. The format of the Parameter Value of this Control Point is UINT16 and represents the crank length in millimeters with a resolution of 1/2 millimeter. The crank length value is typically used as a parameter for internal signal processing. The response shall be indicated when the sensor location is updated in the Server using the *Response Code* Op Code, the *Request* Op Code along with “Success” or other appropriate *Response Value*.

The Server should cache the most recent value of the crank length to avoid reconfiguration of this value by the Client each time a connection is established.

If the operation results in an error condition, or if this Op Code is not supported by the Server, see Section 3.4.3 for details on handling this condition.

This procedure should be used when the bicycle is not moving to avoid unexpected behavior (e.g., inconsistent instantaneous power value).

3.4.2.5 Request Crank Length Procedure

When the *Request Crank Length* Op Code is written to the Cycling Power Control Point and if the Crank Length Adjustment feature is supported by the Server, the Server shall send the current value of the crank length. The response shall be indicated using the *Response Code* Op Code, the *Request* Op Code, the appropriate *Response Value* and, if the procedure succeeds, the *Response Value* shall be set to “Success” followed by the value of the crank length in the Response Parameter. The format of the Response Parameter, in response to this Control Point, is UINT16 and represents the crank length in millimeters with a resolution of 1/2 millimeter.

If the operation results in an error condition, or if this Op Code is not supported by the Server, see Section 3.4.3 for details on handling this condition.

3.4.2.6 Set Chain Length Procedure

When the *Set Chain Length* Op Code is written to the Cycling Power Control Point and if the Chain Length Adjustment feature is supported by the Server, the Server shall store the desired chain length transmitted as a Parameter of the Cycling Power Control Point. The format of the Parameter Value of this Control Point is UINT16 and represents the chain length in millimeters with a resolution of 1 millimeter. The chain length value is typically used as a parameter for internal signal processing. The response shall be indicated when the sensor location is updated in the Server using the *Response Code* Op Code, the *Request* Op Code along with “Success” or other appropriate *Response Value*.

The Server should cache the most recent value of the chain length to avoid reconfiguration of this value by the Client each time a connection is established.

If the operation results in an error condition, or if this Op Code is not supported by the Server, see Section 3.4.3 for details on handling this condition.

This procedure should be used when the bicycle is not moving to avoid unexpected behavior (e.g., inconsistent instantaneous power value).

3.4.2.7 Request Chain Length Procedure

When the *Request Chain Length* Op Code is written to the Cycling Power Control Point and if the Chain Length Adjustment feature is supported by the Server, the Server shall send the current value of the chain length. The response shall be indicated using the *Response Code* Op Code, the *Request* Op Code, the appropriate *Response Value* and, if the procedure succeeds, the *Response Value* shall be set to “Success” followed by the value of the chain length in the Response Parameter. The format of the Response Parameter, in response to this Control Point is UINT16 and represents the chain length in millimeters with a resolution of 1 millimeter.

If the operation results in an error condition, or if this Op Code is not supported by the Server, see Section 3.4.3 for details on handling this condition.

3.4.2.8 Set Chain Weight Procedure

When the *Set Chain Weight* Op Code is written to the Cycling Power Control Point and if the Chain Weight Adjustment feature is supported by the Server, the Server shall store the desired chain weight transmitted as a Parameter of the Cycling Power Control Point. The format of the Parameter Value of this Control Point is UINT16 and represents the chain weight in grams with a resolution of 1 gram. The chain weight value is typically used as a parameter for internal signal processing. The response shall be indicated when the sensor location is updated in the Server using the *Response Code* Op Code, the *Request* Op Code along with “Success” or other appropriate *Response Value*.

The Server should cache the most recent value of the chain weight to avoid reconfiguration of this value by the Client each time a connection is established.

If the operation results in an error condition, or if this Op Code is not supported by the Server, see Section 3.4.3 for details on handling this condition.

This procedure should be used when the bicycle is not moving to avoid unexpected behavior (e.g., inconsistent instantaneous power value).

3.4.2.9 Request Chain Weight Procedure

When the *Request Chain Weight* Op Code is written to the Cycling Power Control Point and if the Chain Weight Adjustment feature is supported by the Server, the Server shall send the current value of the chain weight. The response shall be indicated using the *Response Code* Op Code, the *Request* Op Code, the appropriate *Response Value* and, if the procedure succeeds, the *Response Value* shall be set to “Success” followed by the value of the chain weight in the Response Parameter. The format of the Response Parameter, in response to this Control Point is UINT16 and represents the chain weight in grams with a resolution of 1 gram.

If the operation results in an error condition, or if this Op Code is not supported by the Server, see Section 3.4.3 for details on handling this condition.

3.4.2.10 Set Span Length Procedure

When the *Set Span Length* Op Code is written to the Cycling Power Control Point and if the Span Length Adjustment feature is supported by the Server, the Server shall store the desired span length transmitted as a Parameter of the Cycling Power Control Point. The format of the Parameter Value of this Control Point is UINT16 and represents the span length in millimeters with a resolution of 1 millimeter. The span length value is typically used as a parameter for internal signal processing. The response shall be indicated when the sensor location is updated in the Server using the *Response Code* Op Code, the *Request* Op Code along with “Success” or other appropriate *Response Value*.

The Server should cache the most recent value of the span length to avoid reconfiguration of this value by the Client each time a connection is established.

If the operation results in an error condition, or if this Op Code is not supported by the Server, see Section 3.4.3 for details on handling this condition.

This procedure should be used when the bicycle is not moving to avoid unexpected behavior (e.g., inconsistent instantaneous power value).

3.4.2.11 Request Span Length Procedure

When the *Request Span Length* Op Code is written to the Cycling Power Control Point and if the Span Length Adjustment feature is supported by the Server, the Server shall send the current value of the span length. The response shall be indicated using the *Response Code* Op Code, the *Request* Op Code, the appropriate *Response Value* and, if the procedure succeeds, the *Response Value* shall be set to “Success” followed by the value of the span length in the Response Parameter. The format of the Response Parameter, in response to this Control Point is UINT16 and represents the span length in millimeters with a resolution of 1 millimeter.

If the operation results in an error condition, or if this Op Code is not supported by the Server, see Section 3.4.3 for details on handling this condition.

3.4.2.12 Start Offset Compensation Procedure

When the *Start Offset Compensation* Op Code is written to the Cycling Power Control Point and if the Offset Compensation feature is supported by the Server, the Server shall initiate the offset compensation procedure. The response shall be indicated upon completion of the offset compensation procedure using the *Response Code* Op Code, the *Request* Op Code, the appropriate Response Value and, if the procedure succeeds, the Response Value shall be set to “Success” followed by the value of the force in Newton or the torque in 1/32 Newton meter based on the server capabilities (e.g., based on the Sensor Measurement Context bit of the Cycling Power Feature characteristic as described in Section 3.1) before the offset is compensated in the Response Parameter.

Cycling Power Service

The format of the Response Parameter Value, in response to this Control Point, is SINT16. This Parameter Value represents either the raw force in Newton or the raw torque in 1/32 Newton meter based on the server capabilities (e.g., based on the Sensor Measurement Context of the Cycling Power Feature characteristic defined in 3.1). If the Server does not support the measurement of this value, the Server shall use the special value 0xFFFF which means “Not Available”.

If the operation results in an error condition, or if this Op Code is not supported by the Server, see Section 3.4.3 for details on handling this condition.

3.4.2.13 Mask Cycling Power Measurement Characteristic Content

When the *Mask Cycling Power Measurement Characteristic Content* Op Code is written to the Cycling Power Control Point and if the Cycling Power Measurement Characteristic Content Masking feature is supported by the Server, the Server shall disable unneeded optional fields of the Cycling Power Measurement characteristic based on the transmitted Parameter of the Cycling Power Control Point. The format of the Parameter Value of this Control Point is UINT16 and represents the fields of the Cycling Power Measurement characteristic to turn off as described in Table 3.5.

Bit Number	Description
0	Pedal Power Balance 0: Leave as default 1: Turn off
1	Accumulated Torque 0: Leave as default 1: Turn off
2	Wheel Revolution Data 0: Leave as default 1: Turn off
3	Crank Revolution Data 0: Leave as default 1: Turn off
4	Extreme Magnitudes 0: Leave as default 1: Turn off
5	Extreme Angles 0: Leave as default 1: Turn off
6	Top Dead Spot Angle 0: Leave as default 1: Turn off
7	Bottom Dead Spot Angle 0: Leave as default 1: Turn off
8	Accumulated Energy 0: Leave as default 1: Turn off
9-15	Reserved for future use (RFU)

Table 3.5: Mask Cycling Power Measurement Characteristic Content Procedure Parameter Requirements

Cycling Power Service

This Control Point is typically used to save power in the Server. When the Client does not need a particular optional field of the Cycling Power Measurement characteristic, the Client may turn off that particular field of the Cycling Power Measurement characteristic. This Control Point procedure affects the content of the notification of the Cycling Power Measurement characteristic and may also affect the content of the broadcast of the Cycling Power Measurement characteristic, but this is up to the Server since some data may not be relevant to broadcast. The response shall be indicated when the content of the Cycling Power Measurement characteristic is updated in the Server using the *Response Code Op Code*, the *Request Op Code* along with “Success” or other appropriate *Response Value*.

The Server shall not cache the most recent value of the fields configuration of the Cycling Power Measurement characteristic and each time a connection is established it shall use its default configuration (i.e., none of the fields of the Cycling Power Measurement characteristic are disabled).

If the operation results in an error condition, or if this Op Code is not supported by the Server, see Section 3.4.3 for details on handling this condition.

3.4.2.14 Request Sampling Rate Procedure

When the *Request Sampling Rate Op Code* is written to the Cycling Power Control Point and if the Cycling Power Vector characteristic is supported by the Server, the Server shall send the current value of the sampling rate. The response shall be indicated using the *Response Code Op Code*, the *Request Op Code*, and the appropriate *Response Value* and, if the procedure succeeds, the *Response Value* shall be set to “Success” followed by the value of the sampling rate in the Response Parameter. The format of the Response Parameter, in response to this Control Point, is UINT8 and represents the sampling rate in Hertz with a resolution of 1 Hertz.

If the operation results in an error condition, or if this Op Code is not supported by the Server, see Section 3.4.3 for details on handling this condition.

3.4.2.15 Request Factory Calibration Date Procedure

When the *Request Factory Calibration Date Op Code* is written to the Cycling Power Control Point and if the Factory Calibration Date feature is supported by the Server, the Server shall send the date of the factory calibration. The response shall be indicated using the *Response Code Op Code*, the *Request Op Code*, the appropriate *Response Value* and, if the procedure succeeds, the *Response Value* shall be set to “Success” followed by the value of the factory calibration date in the Response Parameter. The format of the Response Parameter value, in the response to this Control Point, is defined to use the same format as the Date Time characteristic defined in [2]. However, a value of 0 for the year, month or day fields shall not be used.

If the operation results in an error condition, or if this Op Code is not supported by the Server, see Section 3.4.3 for details on handling this condition.

3.4.3 General Error Handling procedures

Other than error handling procedures that are specific to certain Op Codes, the following apply:

Cycling Power Service

If an Op Code is written to the Cycling Power Control Point characteristic that is unsupported by the Server, the Server, after sending a Write Response, shall indicate the Cycling Power Control Point with a *Response Code* Op Code, the *Request Op Code* and *Response Value* set to *Op Code Not Supported*.

If a Parameter is written to the Cycling Power Control Point characteristic that is invalid (e.g., the Client writes the *Update Sensor Location Op Code* with a sensor location that is not valid in the context of the Server, or out of the supported range of the Server), the Server, after sending a Write Response, shall indicate the Cycling Power Control Point with a *Response Code* Op Code, the *Request Op Code* and *Response Value* set to *Invalid Parameter*.

If an Op Code is written to the Cycling Power Control Point characteristic while the Server is performing a previously triggered Cycling Power 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, Section 1.2 [3].

If an Op Code is written to the Cycling Power Control Point characteristic and the *Client Characteristic Configuration* descriptor of the Cycling Power 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, Section 1.2 [3].

3.4.4 Procedure Timeout

In the context of the Cycling Power Control Point characteristic, a procedure is started when a write to the Cycling Power Control Point characteristic is successfully completed (i.e., the Server sends a Write Response). When a procedure is complete, the Server shall indicate the Cycling Power Control Point with the Op Code set to *Response Code*.

In the context of the Cycling Power Control Point characteristic, a procedure is not considered started and not queued in the Server when a write to the Cycling Power Control Point results in an error response with the Attribute Protocol error code defined in CSS Part B, Section 1.2 [3].

3.5 Cycling Power Vector

The Cycling Power Vector characteristic is used to send raw data (either force or torque). Included in the characteristic value are a Flags field (for showing the presence of optional fields) and depending upon the contents of the Flags field, a Crank Revolution Data field (which includes a Cumulative Crank Revolutions field and Last Crank Event Time field), a First Crank Measurement Angle field. The Cycling Power Vector also includes an Instantaneous Magnitude Array field.

The Server measures the force-related data (or torque-related data) the cyclist is producing and cadence-related data which represents the number of times per minute the cyclist turns the crank. The Instantaneous Magnitude values of the Instantaneous Magnitude Array field are related to a crank revolution and because the cadence varies along with the time, the amount of Instantaneous Magnitude values per crank rotations also varies. The First Crank Measurement Angle shall be present when the Server

Cycling Power Service

detects the beginning of a new crank revolution. If a cyclist rotates the pedals at a cadence of 90 revolutions per minute and the sampling rate of Server is 25 Hertz, there should be 16 or 17 Instantaneous Magnitude values per crank revolution.

3.5.1 Characteristic Behavior

When the Cycling Power Vector characteristic is configured for notification via the *Client Characteristic Configuration* descriptor and a force-related measurement (or torque-related measurement) is available, this characteristic shall be notified. The Server should notify this characteristic at regular interval while in a connection and is not configurable by the Client.

In typical applications, the Cycling Power Vector characteristic is notified approximately once per 100 or 300 milliseconds, depending on the sampling rate of the transmitted data. The transmission interval is typically related to the sampling rate at which the Server samples the data. The sampling rate referenced in this section is not necessarily the sampling rate at which the Server samples the raw signal, but it represents the sampling rate at which the Instantaneous Magnitude values present in the Cycling Power Vector characteristic are sampled since those data are typically down sampled from the raw signal.

The value of the sampling rate used to send the Cycling Power Vector data can be requested using the procedure described in Section 3.4.2.14.

When a Client writes 0x0001 to the *Client Characteristic Configuration* descriptor to start the notifications, the Server may request new connection parameters (e.g. using the GAP Connection Parameter Update procedure described in Volume 3 Part C Section 9.3.9 of [1]) before the notifications are sent if the current connection parameters do not allow the sending of notification (e.g., the Server requires faster connection interval). If the Client does not change the connection parameters within a period of time defined by the Server (e.g., 7 seconds or more if the current connection interval is set to 1 second), the Server shall return an *ATT Error Response* to the *Write Request* with an *Error Code* set to the *Application Error Code* 0x80 (Inappropriate Connection Parameters). Otherwise, the Server shall respond with a *Write Response* and start sending notifications of the Cycling Power Vector characteristic.

When a Client writes 0x0000 to the *Client Characteristic Configuration* descriptor to stop the notifications, the Server should send a request to the Client to set the connection parameters to the same values as before the Client started the notifications (e.g., using the GAP Connection Parameter Update procedure described in Volume 3 Part C Section 9.3.9 of [1]).

Refer to Section 3.7 for additional recommendations for distributed power sensor systems (e.g., one CP Sensor on each pedal measuring the left and right power contribution).

The Cycling Power Vector characteristic contains time-sensitive data, thus the requirements for time-sensitive data and data storage defined in Section 3.6 apply.

3.5.1.1 Flags Field

The Flags field shall be included in the Cycling Power Vector characteristic.

Cycling Power Service

Reserved for Future Use (RFU) bits in the Flags fields shall be set to 0.

The bits of the Flags field, their function, and relationship to bits in the Cycling Power Feature characteristic are shown in [Table 3.6](#).

Flags Bit Name	When Set To		Corresponding Cycling Power Feature support bit
	0	Otherwise	
Crank Revolution Data Present (bit 0), see 3.5.1.2	Corresponding field pair not present	Corresponding field pair present	Crank Revolution Data Supported (bit 3)
First Crank Measurement Angle Present (bit 1), see 3.5.1.3	Corresponding field not present	Corresponding field present	Extreme Angles Supported (bit 5).
Instantaneous Force Magnitude Array Present (bit 2), see 3.5.1.4	Corresponding field not present	Corresponding field present	Sensor Measurement Context set to Force-based (bit 16)
Instantaneous Torque Magnitude Array Present (bit 3), see 3.5.1.5	Corresponding field not present	Corresponding field present	Sensor Measurement Context set to Torque-based (bit 16)
Instantaneous Measurement Direction (bits 4-5), see 3.5.1.4 and 3.5.1.5	Unknown direction	See direction definitions in [2]	Instantaneous Measurement Direction Supported (bit 17)

Table 3.6: Bit Definitions for the Cycling Power Vector Characteristic

Each of the Flags bits in the table above may change during a connection if the corresponding support bit in the Cycling Power Feature characteristic is set to 1 indicating that the feature is supported. If the corresponding support bit is however set to 0, then the corresponding Flags bit shall also be set to 0 since the feature is not supported. See Table 3.3 for further information on the Cycling Power Feature characteristic support bits and static requirements.

3.5.1.2 Crank Revolution Data Field Pair

The Crank Revolution Data field pair (Cumulative Crank Revolutions and Last Crank Event Time fields), which represents the number of times a crank rotates, is used in combination with the Last Crank Event Time to enable the Client to:

- 1) Determine if the cyclist is coasting,
- 2) Calculate the instantaneous and average cadence and
- 3) Rebuild a measurement vector based on the Crank Revolution Data and the First Crank Measurement Angle value.

Average cadence is not accurate unless 0 cadence events (i.e., coasting) are subtracted. In addition, if there is link loss, the Cumulative Crank Revolutions value can be used to calculate the average cadence during the link loss. This value is intended to roll over and is not configurable.

The ‘crank event time’ is a free-running-count of 1/1024 second units and it represents the time when the crank revolution was detected by the crank rotation sensor. Since several crank events can occur between transmissions, only the Last Crank Event Time value is transmitted.

The Last Crank Event Time value rolls over every 64 seconds.

To enhance the user experience, the Server should ignore the extra crank revolutions that may be detected when the user is not pedaling (e.g., coasting down the hill) but the sensor is facing the magnet installed on the crankset and may cause unwanted crank revolution detections.

3.5.1.3 First Crank Measurement Angle Field

If the Server supports the Extreme Angles feature (see [Table 3.6](#)), this field shall be supported, but is not necessarily required in every packet.

This represents the angle of the first sample at the start of a measurement and is used by the Client in conjunction with the Instantaneous Magnitude values and the Sampling Rate to assemble a force (or torque) vector array to show a user the forces throughout a crank rotation. If there are more Instantaneous Magnitude values for a rotation than will fit within a single packet, then the next packet shall include the remaining values, however the First Crank Measurement Angle field shall not be present in the continuation packet.

3.5.1.4 Instantaneous Force Magnitude Array Field

If the Sensor Measurement Context bit of the Cycling Power Feature characteristic is set to 0 (Force-based), then this field shall be supported, but is not necessarily required in every packet (see [Table 3.6](#)). Otherwise, this field is excluded from this characteristic. The support of this field excludes the support of the Instantaneous Torque Magnitude Array field.

The Instantaneous Force Magnitude Array field is a variable length field and it may be included in the Cycling Power Vector characteristic. Included in this field are one or more Instantaneous Magnitude values which are expressed in Newton with a resolution of 1 Newton. These values represent the raw data the sensor measures. The sampling rate at which these data are sampled can be requested using the *Request Sampling Rate* procedure defined in [Section 3.4.2.14](#)).

The Instantaneous Measurement Direction bits of the Flags field describe the direction of the Instantaneous Magnitude values the Server measures (e.g., Unknown, Tangential Component, Radial Component, or Lateral Component).

The number of values in the array is related to the sampling rate of the sensor and the notification interval.

For LE Transport, the following restrictions exist for a 23-octet ATT_MTU,

- The maximum number of Instantaneous Magnitude values that can be notified if Crank Revolution Data and First Crank Measurement Angle are present is 6.
- The maximum number of Instantaneous Magnitude values that can be notified if Crank Revolution Data is not present and First Crank Measurement Angle is present is 8.
- The maximum number of Instantaneous Magnitude values that can be notified if Crank Revolution Data is present and First Crank Measurement Angle is not present is 7.

Cycling Power Service

- The maximum number of Instantaneous Magnitude values that can be notified if Crank Revolution Data and First Crank Measurement Angle are not present is 9.

If more Instantaneous Magnitude values are measured since the last notification than fit into one Cycling Power Vector characteristic, then the Instantaneous Magnitude values should be included in the next available Cycling Power Vector in a continuation packet as described in Section 3.5.1.3.

Since a Server supports only one measurement context (e.g., Force-based or Torque-based), the support of this field excludes the support of the Instantaneous Torque Magnitude Array field.

3.5.1.5 Instantaneous Torque Magnitude Array Field

If the Sensor Measurement Context bit of the Cycling Power Feature characteristic is set to 1 (Torque-based), then this field shall be supported, but it is not necessarily required in every packet (see Table 3.6). Otherwise, this field is excluded from this characteristic. The support of this field excludes the support of the Instantaneous Torque Magnitude Array field.

The Instantaneous Torque Magnitude Array field is a variable length field and it may be included in the Cycling Power Vector characteristic. Included in this field are one or more Instantaneous Magnitude values which are expressed in Newton meter with a resolution of 1/32 Newton meter. These values represent the raw data the sensor measures. The sampling rate at which these data are sampled can be requested using the *Request Sampling Rate* procedure defined in Section 3.4.2.14).

The Instantaneous Measurement Direction bits of the Flags field describe the direction of the Instantaneous Magnitude values the Server measures (e.g., Unknown, Tangential Component, Radial Component, or Lateral Component).

The number of values in the array is related to the sampling rate of the sensor and the notification interval.

For LE Transport, the following restrictions exist for a 23-octet ATT_MTU,

- The maximum number of Instantaneous Magnitude values that can be notified if Crank Revolution Data and First Crank Measurement Angle are present is 6.
- The maximum number of Instantaneous Magnitude values that can be notified if Crank Revolution Data is not present and First Crank Measurement Angle is present is 8.
- The maximum number of Instantaneous Magnitude values that can be notified if Crank Revolution Data is present and First Crank Measurement Angle is not present is 7.
- The maximum number of Instantaneous Magnitude values that can be notified if Crank Revolution Data and First Crank Measurement Angle are not present is 9.

If more Instantaneous Magnitude values are measured since the last notification than fit into one Cycling Power Vector characteristic, then the Instantaneous Magnitude values should be included in the next available Cycling Power Vector in a continuation packet as described in Section 3.5.1.3.

Cycling Power Service

Since a Server supports only one measurement context (e.g., Force-based or Torque-based), the support of this field excludes the support of the Instantaneous Force Magnitude Array field.

3.6 Requirements for Time-Sensitive Data

The Cycling Power Measurement characteristic as well as the Cycling Power Vector characteristic contain time sensitive data and are considered time-sensitive characteristics, thus the following requirements apply:

Since this service does not provide any data with a time stamp to identify the measurement time (and age) of the data, the value of the Cycling Power Measurement characteristic or the value of the Cycling Power Vector characteristic shall be discarded if either the connection does not get established or if the notification is not successfully transmitted (e.g., due to link loss).

3.7 Requirements for Servers Used for a Distributed Power System

The Instantaneous Power field of the Cycling Power Measurement characteristic of each Server represents a part of the total power (e.g., what is measured). The Client can calculate the total power based on each of these values.

4 SDP Interoperability

If this service is exposed over BR/EDR then it shall have the following SDP record.

Item	Definition	Type	Value	Status
Service Class ID List				M
Service Class #0		UUID	«Cycling Power»	M
Protocol Descriptor List				M
Protocol #0		UUID	L2CAP	M
Parameter #0 for Protocol #0	PSM	Uint16	PSM = ATT	M
Protocol #1		UUID	ATT	M
Parameter #0 for Protocol #1	GATT Start Handle	Uint16	First handle of this service in the GATT database	M
Parameter #1 for Protocol #1	GATT End Handle	Uint16	Last handle of this service in the GATT database	M
BrowseGroupList			PublicBrowseRoot*	M

Table 4.1: SDP Record

* PublicBrowseRoot shall be present; however, other browse UUIDs may also be included in the list.

5 Acronyms and Abbreviations

Acronyms and Abbreviations	Meaning
AMP	Alternate MAC/PHY
BR/EDR	Basic Rate / Enhanced Data Rate
GAP	Generic Access Profile
GATT	Generic Attribute Profile
LE	Low Energy
RFU	Reserved for Future Use
SDP	Service Discovery Protocol
UUID	Universally Unique Identifier

Table 5.1: Acronyms and Abbreviations

6 References

- [1] Bluetooth Core Specification v4.0 with CSA2, CSA3 and CSA4 or later version of the Core Specification.
- [2] Characteristic and Descriptor descriptions are accessible via the [Bluetooth SIG Assigned Numbers](#).
- [3] Supplement to the Bluetooth Core Specification, Version 2 or later