Audio Input Control Service

Bluetooth® Service Specification

- **Version:** v1.0.1
- **Version Date:** 2025-02-11
- **Prepared By:** Generic Audio Working Group

Abstract

This specification describes the service that exposes the gain of an audio input.

Version History

Version Number	Date	Comments
v1.0	2020-12-15	Adopted by the Bluetooth SIG Board of Directors.
v1.0.1	2025-02-11	Adopted by the Bluetooth SIG Board of Directors.

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Contents

1   Introduction

This service enables a device to expose the control and state of an audio input.

1.1   Conformance

Each capability of this specification shall be supported in the specified manner. This specification may provide options for design flexibility, because, for example, some products do not implement every portion of the specification. For each implementation option that is supported, it shall be supported as specified.

1.2   Service dependencies

This service is not dependent upon other services.

1.3   Bluetooth Core Specification release compatibility

This specification is compatible with any version of the Bluetooth Core Specification [1] that includes the Generic Attribute Profile (GATT).

1.4   GATT sub-procedure requirements

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

Requirements in this section are defined as "Mandatory" (M), "Optional" (O), "Excluded" (X), and "Conditional" (C.*n*). Conditional statements (C.*n*) are listed directly below the table in which they appear.

Table 1.1 summarizes additional GATT sub-procedure requirements beyond those required by all GATT servers over Unenhanced Attribute Protocol (ATT) bearers.

GATT Sub-Procedure	Requirements
Write Characteristic Values	M
Notifications	M
Read Characteristic Descriptors	M
Write Characteristic Descriptors	M

Table 1.1: GATT sub-procedure requirements, Unenhanced ATT bearers

1.5   Transport dependencies

This service uses GATT and therefore has no additional transport dependencies.

Notifications with GATT are considered unreliable when used with an Unenhanced ATT bearer.

An Enhanced ATT bearer can be used for reliability of Notifications and can be specified by a higher-layer profile.

1.6   Application error codes

This service defines the ATT Application error codes shown in Table 1.2.

Name	Error Code	Description
Invalid Change Counter	0x80	The Change_Counter operand value does not match the Change_Counter field value of the Audio Input State characteristic.
Opcode Not Supported	0x81	An invalid opcode has been used in a control point procedure.
Mute Disabled	0x82	Mute/unmute commands are disabled.
Value Out of Range	0x83	An operand value used in a control point procedure is outside the permissible range.
Gain Mode Change Not Allowed	0x84	A requested gain mode change is not allowed.

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 (LSO) first (i.e., little endian). The LSO is identified in the characteristic definitions in the Bluetooth SIG Assigned Numbers [3].

1.8   Change History

This section summarizes changes at a moderate level of detail and should not be considered representative of every change made.

1.8.1   Changes from v1.0 to v1.0.1

Section	Errata
1.1: Conformance	23754
3.1.2: Mute field	26031
3.1.3: Gain_Mode field	26032
3.5.2.2: Unmute procedure	26031
3.5.2.3: Mute procedure	26031
3.5.2.5: Set Automatic Gain Mode procedure	16466
6: References	19294

Table 1.3: Errata incorporated in v1.0.1

1.9   Language

1.9.1   Language conventions

The Bluetooth SIG has established the following conventions for use of the words *shall*, *must*, *will*, *should*, *may*, *can*, *is*, and *note* in the development of specifications:

shall	<u>is required to</u> – used to define requirements.
must	is used to express: a natural consequence of a previously stated mandatory requirement. OR an indisputable statement of fact (one that is always true regardless of the circumstances).
will	<u>it is true that</u> – only used in statements of fact.
should	<u>is recommended that</u> – used to indicate that among several possibilities one is recommended as particularly suitable, but not required.
may	<u>is permitted to</u> – used to allow options.
can	<u>is able to</u> – used to relate statements in a causal manner.
is	<u>is defined as</u> – used to further explain elements that are previously required or allowed.
note	Used to indicate text that is included for informational purposes only and is not required in order to implement the specification. Each note is clearly designated as a "Note" and set off in a separate paragraph.

For clarity of the definition of those terms, see Core Specification Volume 1, Part E, Section 1.

1.9.2   Reserved for Future Use

Where a field in a packet, Protocol Data Unit (PDU), or other data structure is described as "Reserved for Future Use" (irrespective of whether in uppercase or lowercase), the device creating the structure shall set its value to zero unless otherwise specified. Any device receiving or interpreting the structure shall ignore that field; in particular, it shall not reject the structure because of the value of the field.

Where a field, parameter, or other variable object can take a range of values, and some values are described as "Reserved for Future Use," a device sending the object shall not set the object to those values. A device receiving an object with such a value should reject it, and any data structure containing it, as being erroneous; however, this does not apply in a context where the object is described as being ignored or it is specified to ignore unrecognized values.

When a field value is a bit field, unassigned bits can be marked as Reserved for Future Use and shall be set to 0. Implementations that receive a message that contains a Reserved for Future Use bit that is set to 1 shall process the message as if that bit was set to 0, except where specified otherwise.

The acronym RFU is equivalent to Reserved for Future Use.

1.9.3   Prohibited

When a field value is an enumeration, unassigned values can be marked as "Prohibited." These values shall never be used by an implementation, and any message received that includes a Prohibited value shall be ignored and shall not be processed and shall not be responded to.

Where a field, parameter, or other variable object can take a range of values, and some values are described as "Prohibited," devices shall not set the object to any of those Prohibited values. A device receiving an object with such a value should reject it, and any data structure containing it, as being erroneous.

"Prohibited" is never abbreviated.

1.9.4   Terminology

Table 1.4 defines terms that are needed to understand features used in this service.

Term	Definition
Unenhanced ATT bearer	An ATT bearer not using the Enhanced Credit Based Flow Control Logical Link Control and Adaptation Protocol (L2CAP) channel mode introduced in Volume 3, Part A, Section 10.2 in the Bluetooth Core Specification [2].
Enhanced ATT bearer	An ATT bearer using the Enhanced Credit Based Flow Control L2CAP channel mode introduced in Volume 3, Part A, Section 10.2 in [2].

Table 1.4: Terminology

2 Service

2.1 Declaration

There may be one or more instances of the Audio Input Control Service on a device.

The Audio Input Control Service is instantiated to expose the settings of an audio input such as a Bluetooth audio stream, microphone, etc. Multiple audio inputs may be combined as part of the server's audio mixing functionality.

The Attribute Type service declaration shall be set to the «Secondary Service» universally unique identifier (UUID), and the Attribute Value service declaration shall be set to «Audio Input Control Service» as defined in the Bluetooth SIG Assigned Numbers [3]. The Audio Input Control Service shall only be instantiated as an included service.

2.2 Overview

This section provides an overview of the behavior of the characteristics that affect the audio input's gain and their usage.

2.2.1 Audio Input State

The Audio Input State characteristic value consists of four fields: the Gain_Setting field, Mute field, Gain_Mode field, and Change_Counter field.

2.2.1.1 Gain_Setting field

The Gain_Setting field controls the amplitude of an individual audio input that the server controls, such as a Bluetooth audio stream or microphone.

The Gain_Setting field is a signed value for which a single increment or decrement should result in a corresponding increase or decrease of the input amplitude by the value of the Gain_Setting_Units field of the Gain Setting Properties characteristic value. A Gain_Setting value of 0 should result in no change to the input's original amplitude.

The Gain_Setting field's resolution and range, in decibels (dB), are described by the Gain Setting Properties characteristic value. The Gain_Setting value shall be less than or equal to the Gain_Setting_Maximum field and greater than or equal to the Gain_Setting_Minimum field of the Gain Setting Properties characteristic value.

If the Gain_Mode field value is Automatic or Automatic Only, then the Gain_Setting field does not affect the audio input and the server should ignore the Gain_Setting field's value.

2.2.1.2 Mute field

The Mute field describes the mute state of the audio input. The Mute field values are described in Table 2.1.

Mute Field	Value
Not Muted	0
Muted	1
Disabled	2

Table 2.1: Mute field values

The Mute field value represents the server's audio state where a value of Not Muted represents unmuted audio, a value of Muted represents muted audio, and a value of Disabled represents that mute commands are disabled, for example via a local privacy switch or other means.

The Mute field value shall not affect the Gain_Setting field value; for example, muting a server shall not change the Gain_Setting field value to the Gain_Setting_Minimum field value.

2.2.1.3   Gain_Mode field

The Gain_Mode field describes whether the server automatically sets the audio input's gain. This field allows a server to expose control over the gain mode of an audio input. An example of selectable gain mode control is a microphone that can automatically adjust its gain through automatic gain control or allows the gain to be set manually.

The Gain_Mode field values are described in Table 2.2.

Gain_Mode Field	Value
Manual Only	0
Automatic Only	1
Manual	2
Automatic	3

Table 2.2: Gain_Mode field values

The Gain_Mode field value represents the server's gain adjustment functionality.

A value of Manual or Manual Only indicates that gain adjustments are made manually through changes to the Gain_Setting field. A value of Automatic or Automatic Only represents automatic gain adjustment where the Gain_Setting field is ignored.

When the value of the Gain_Mode field is either Automatic Only or Manual Only, the server does not support changes to the Gain_Mode field. When the value of the Gain_Mode field is either Automatic or Manual, the server supports switching between the Automatic and Manual values of the Gain_Mode field.

2.2.1.4   Change_Counter field

The server shall increment the Change_Counter field value by one upon every change to the Gain_Setting, Mute, and Gain_Mode field values. The Change_Counter field value is used in all Audio Input Control Point commands.

The server shall initialize the Change_Counter field to an arbitrary value. The value shall be in the range of 0 to 255, and an increment larger than 255 shall roll over to 0.

3   Service characteristics

This section defines the characteristic and descriptor requirements.

Requirements in this section are defined as "Mandatory" (M), "Optional" (O), "Excluded" (X), and "Conditional" (C.*n*). Conditional statements (C.*n*) are listed directly below the table in which they appear.

Characteristic Name	Requirement	Mandatory Properties	Optional Properties	Security Permissions
Audio Input State	M	Read, Notify	None	Encryption Required
Gain Setting Properties	M	Read	None	Encryption Required
Audio Input Type	M	Read	None	Encryption Required
Audio Input Status	M	Read, Notify	None	Encryption Required
Audio Input Control Point	M	Write	None	Encryption Required
Audio Input Description	M	Read, Notify [C.1]	Write Without Response, Notify	Encryption Required

Table 3.1: Audio Input Control Service characteristics

C.1:   Mandatory to support Notify if Write Without Response is supported, otherwise Optional.

Properties not listed as Mandatory or Optional in Table 3.1 are Excluded.

3.1   Audio Input State

The Audio Input State characteristic shall be used to reflect the state of the audio gain and mute of the input to which this service applies. The value of the Audio Input State characteristic shall use the format described in Table 3.2.

Field Name	Size (Octets)	Format
Gain_Setting	1	int8
Mute	1	uint8
Gain_Mode	1	uint8
Change_Counter	1	uint8

Table 3.2: Audio Input State characteristic value format

3.1.1   Gain_Setting field

The Gain_Setting field shall be set to a value that reflects the current gain of the audio input signal to which this service applies. A single increment or decrement of the Gain_Setting field value is equal to the Gain_Setting_Units field value, as described in Section 2.2.1.1.

The Gain_Setting field is applied as described in Section 2.2.1.1.

3.1.2   Mute field

The Mute field shall be set to a value that reflects the current mute state of the audio to which this service applies. The server may autonomously change the Mute field value to or from Disabled to another value. Note that the client cannot change the Mute field value to or from Disabled.

The Mute field is applied as described in Section 2.2.1.2.

3.1.3   Gain_Mode field

The Gain_Mode field shall be set to a value that reflects whether gain modes are manual or automatic. The server may autonomously change the Gain_Mode field value to or from Manual Only or Automatic Only to another value. Note the client cannot change the value of the Gain_Mode field to or from Automatic Only or Manual Only. The server allows only manual gain if the Gain_Mode field value is Manual Only; only automatic gain if the Gain_Mode field is Automatic Only; and switchable automatic/manual gain for other values.

The Gain_Mode field is applied as described in Section 2.2.1.3.

3.1.4   Change_Counter field

The server shall initialize the Change_Counter field to an arbitrary value. The Change_Counter field value shall be incremented by 1 when the Gain_Setting, Mute, or Gain_Mode field value changes and shall not be changed otherwise. When the Change_Counter field value reaches 255, its next increment shall be 0.

3.1.5   Audio Input State behavior

The Audio Input State characteristic value may be read by the client. When the Audio Input State value changes, the server shall notify clients that have enabled the Client Characteristic Configuration Descriptor for notifications of the new value. The Audio Input State characteristic value shall be the same for all clients.

3.2   Gain Setting Properties

The Gain Setting Properties characteristic shall be set to a value that reflects the limits and units of the Gain_Setting field value. The value of the Gain Setting Properties characteristic shall use the format described in Table 3.3.

Field Name	Size (Octets)	Format
Gain_Setting_Units	1	uint8
Gain_Setting_Minimum	1	int8
Gain_Setting_Maximum	1	int8

Table 3.3: Gain Setting Properties characteristic value format

3.2.1   Gain_Setting_Units field

The Gain_Setting_Units characteristic shall be set to a value that reflects the size of a single increment or decrement of the Gain Setting value in 0.1 decibel units.

The Gain_Setting_Units is applied as described in Section 2.2.1.1.

3.2.2   Gain_Setting_Minimum field

The Gain_Setting_Minimum field shall be set to a value that reflects the minimum allowable value of the Gain_Setting field value of this service, including the value of the operand used in Section 3.5.2.1.

The Gain_Setting_Minimum field value shall be less than or equal to the Gain_Setting_Maximum field value.

3.2.3   Gain_Setting_Maximum field

The Gain_Setting_Maximum field shall be set to a value that reflects the maximum allowable value of the Gain_Setting field value of this service, including the value of the operand used in Section 3.5.2.1.

The Gain_Setting_Maximum field value shall be greater than or equal to the Gain_Setting_Minimum field value.

3.2.4   Gain Setting Properties behavior

The Gain Setting Properties characteristic value may be read by the client. The server shall not change this value while connected to a client.

3.3   Audio Input Type

The Audio Input Type characteristic shall be set to a value that reflects the source of audio for the audio input described by this Audio Input Control Service. Examples of Audio Input Type values are Local, Isochronous Stream, Analog Connector, and Digital Connector. The Characteristic User Description may optionally further describe the Audio Input Type with values such as Microphone, HDMI, etc. The Audio Input Type characteristic value is defined in the Bluetooth SIG Assigned Numbers [3].

3.3.1   Audio Input Type behavior

The Audio Input Type characteristic value may be read by the client. The server shall not change this value while connected to a client.

3.4   Audio Input Status

The Audio Input Status characteristic shall be set to a value that reflects the current state of the audio input. The Audio Input Status is a one-octet value that shall have one of the non-RFU values defined in Table 3.4.

Name	Value
Inactive	0x00
Active	0x01
RFU	0x02–0xFF

Table 3.4: Audio Input Status values

3.4.1   Audio Input Status behavior

The Audio Input Status characteristic value may be read by the client. When the Audio Input Status value changes, the server shall notify clients that have enabled the Client Characteristic Configuration Descriptor for notifications of the new value.

3.5   Audio Input Control Point

The Audio Input Control Point characteristic is used to request a specific procedure to be executed by the server when a value is written to it.

3.5.1   Audio Input Control Point procedure requirements

Table 3.5 lists the requirements for the Audio Input Control Point procedures for the request opcodes and operands in the context of this Audio Input Control Service.

Opcode Value	Opcode	Procedure Section	Opcode Requirement	Operand
0x01	Set Gain Setting	Section 3.5.2.1	M	Change_Counter, Gain_Setting
0x02	Unmute	Section 3.5.2.2	M	Change_Counter
0x03	Mute	Section 3.5.2.3	M	Change_Counter
0x04	Set Manual Gain Mode	Section 3.5.2.4	M	Change_Counter
0x05	Set Automatic Gain Mode	Section 3.5.2.5	M	Change_Counter

Table 3.5: Audio Input Control Point procedure requirements

3.5.2   Audio Input Control Point behavior

The Audio Input Control Point characteristic value may be written by the client.

If a client writes a Change_Counter operand that does not equal the Change_Counter field of the Audio Input State characteristic value, then the server shall return an ATT Error Response with the error code Invalid Change Counter defined in Table 1.2.

If a client writes an opcode that is not supported or not defined in Table 3.5, then the server shall return an ATT Error Response with the error code Opcode Not Supported defined in Table 1.2.

3.5.2.1   Set Gain Setting procedure

If the Set Gain Setting opcode is written to the Audio Input Control Point and the Change_Counter operand matches the Change_Counter field of the Audio Input State characteristic value, then the server shall set the Gain_Setting field value to the Gain_Setting operand value if the Gain_Mode field is Manual or Manual Only. If the Set Gain Setting procedure causes the Gain_Setting field value to change, the server shall notify clients of the new Audio Input State value, as described in Section 3.1.5.

If the Gain_Setting operand value is less than the Gain_Setting_Minimum field value or greater than the Gain_Setting_Maximum field value, then the server shall return an ATT Error Response with the error code Value Out of Range defined in Table 1.2.

The Set Gain Setting procedure shall not affect the Mute field value.

The Audio Input Control Point characteristic value used for the Set Gain Setting Procedure shall be formatted as listed in Table 3.6.

Parameter	Size (Octets)	Value
Opcode	1	0x01 = Set Gain Setting Opcode
Change_Counter	1	0x00–0xFF
Gain_Setting	1	-128 to 127

Table 3.6: Set Gain Setting format

3.5.2.2   Unmute procedure

If the Unmute opcode is written to the Audio Input Control Point, the Change_Counter operand matches the Change_Counter field of the Audio Input State characteristic value, and the Mute field value is not Disabled, then the server shall set the Mute field value to Not Muted.

If the Mute field value is Disabled, the server shall return an ATT Error Response with the error code Mute Disabled defined in Table 1.2.

If the Unmute procedure causes the Mute field value to change, the server shall increment the Change_Counter and notify clients of the new Audio Input State characteristic value, as described in Section 3.1.5.

The Audio Input Control Point characteristic value used for the Unmute Procedure shall be formatted as listed in Table 3.7.

Parameter	Size (Octets)	Value
Opcode	1	0x02 = Unmute Opcode
Change_Counter	1	0x00-0xFF

Table 3.7: Unmute format

3.5.2.3   Mute procedure

If the Mute opcode is written to the Audio Input Control Point, the Change_Counter operand matches the Change_Counter field of the Audio Input State characteristic value, and the Mute field value is not Disabled, the server shall set the Mute field value to Muted.

If the Mute field value is Disabled, the server shall return an ATT Error Response with the error code Mute Disabled defined in Table 1.2.

If the Mute procedure causes the Mute field value to change, the server shall increment the Change_Counter field value and notify clients of the new Audio Input State characteristic value, as described in Section 3.1.5.

The Audio Input Control Point characteristic value used for the Mute Procedure shall be formatted as listed in Table 3.8.

Parameter	Size (Octets)	Value
Opcode	1	0x03 = Mute Opcode
Change_Counter	1	0x00-0xFF

Table 3.8: Mute format

3.5.2.4   Set Manual Gain Mode procedure

If the Set Manual Gain Mode opcode is written to the Audio Input Control Point, and the Change_Counter operand matches the Change_Counter field of the Audio Input State characteristic value, the server shall set the Gain_Mode field value to Manual if the Gain_Mode field value is Automatic.

If the Gain_Mode field value is Automatic Only or Manual Only, the server shall return an ATT Error Response to with the error code Gain Mode Change Not Allowed defined in Table 1.2.

If the Set Manual Gain Mode procedure results in a change to the Gain_Mode field value, the server shall increment the Change_Counter field value and notify clients of the new Audio Input State characteristic value, as described in Section 3.1.5.

The Audio Input Control Point characteristic value used for the Set Manual Gain Mode Procedure shall be formatted as listed in Table 3.9.

Parameter	Size (Octets)	Value
Opcode	1	0x04 = Set Manual Gain Mode Opcode
Change_Counter	1	0x00-0xFF

Table 3.9: Set Manual Gain Mode format

3.5.2.5   Set Automatic Gain Mode procedure

If the Set Automatic Gain Mode opcode is written to the Audio Input Control Point, and the Change_Counter operand matches the Change_Counter field of the Audio Input State characteristic value, the server shall set the Gain_Mode field value to Automatic if the Gain_Mode field value is Manual.

If the Gain_Mode field value is Automatic Only or Manual Only, the server shall return an ATT Error Response with the error code Gain Mode Change Not Allowed defined in Table 1.2.

If the Set Automatic Gain Mode procedure results in a change to the Gain_Mode field value, the server shall increment the Change_Counter field value and notify clients of the new Audio Input State characteristic value, as described in Section 3.1.5.

The Audio Input Control Point characteristic value used for the Set Automatic Gain Mode Procedure shall be formatted as listed in Table 3.10.

Parameter	Size (Octets)	Value
Opcode	1	0x05 = Set Automatic Gain Mode Opcode
Change_Counter	1	0x00-0xFF

Table 3.10: Set Automatic Gain Mode format

3.6   Audio Input Description

The Audio Input Description characteristic shall be set to a description of the audio input that the Audio Input Control Service instance describes. For example, if a device instantiated a service for both "Bluetooth" and "Line In" audio inputs, then the Audio Input Description value would be set to "Bluetooth" on one service and "Line In" on the other service. If multiple Bluetooth audio inputs are represented, the server may set the Audio Input Description to the remote source's name, a string representing the content

type, the content control server name, etc. The characteristic value is a UTF-8 string of zero or more characters.

3.6.1   Audio Input Description behavior

The Audio Input Description characteristic value may be read and optionally written by the client. When the Audio Input Description value changes, the server shall notify clients that have enabled the Client Characteristic Configuration Descriptor for notifications of the new value if the server supports notifications of this characteristic.

4 SDP interoperability

If the Audio Input Control Service is exposed over Basic Rate/Enhanced Data Rate (BR/EDR), then the service shall have the Service Discovery Protocol (SDP) record defined in Table 4.1.

Requirements in this section are defined as "Mandatory" (M), "Optional" (O), "Excluded" (X), and "Conditional" (C.*n*). Conditional statements (C.*n*) are listed directly below the table in which they appear.

Item	Definition	Type	Value	Status
Service Class ID List	–	–	–	M
Service Class #0	–	UUID	«Audio Input Control Service»	M
Protocol Descriptor List	–	Data Element Sequence	–	M
Protocol #0	–	UUID	«L2CAP»	M
Parameter #0 for Protocol #0	Protocol/Service Multiplexer (PSM)	uint16	PSM = ATT	M
Protocol #1	–	UUID	«ATT»	M
Additional Protocol Descriptor List	–	Data Element Sequence	–	C.1
Protocol Descriptor List	–	Data Element Sequence	–	C.1
Protocol #0	–	UUID	«L2CAP»	C.1
Parameter #0 for Protocol #0	PSM	uint16	PSM = EATT	C.1
Protocol #1	–	UUID	«ATT»	C.1
BrowseGroupList	–	–	PublicBrowseRoot Other browse UUIDs may also be included in the list.	M

Table 4.1: SDP record

C.1:   Mandatory if Enhanced Attribute Protocol (EATT), introduced in Volume 3, Part F, Section 3.2.11 in [2], is supported, otherwise Excluded.

5 Acronyms and abbreviations

Acronym/Abbreviation	Meaning
ATT	Attribute Protocol
BR/EDR	Basic Rate/Enhanced Data Rate
EATT	Enhanced Attribute Protocol
GATT	Generic Attribute Profile
L2CAP	Logical Link Control and Adaptation Protocol
LSO	least significant octet
PDU	Protocol Data Unit
PSM	Protocol/Service Multiplexer
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 (amended) Version 4.2 or later

[2]   Bluetooth Core Specification (amended) Version 5.2 or later

[3]   Bluetooth SIG Assigned Numbers, https://www.bluetooth.com/specifications/assigned-numbers