Hearing Access Service (HAS)

Bluetooth® **Test Suite**

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Contents

1   Scope

This Bluetooth document contains the Test Suite Structure (TSS) and test cases to test the implementation of the Bluetooth Hearing Access Service with the objective to provide a high probability of air interface interoperability between the tested implementation and other manufacturers' Bluetooth devices.

2   References, definitions, and abbreviations

2.1   References

This document incorporates provisions from other publications by dated or undated reference. These references are cited at the appropriate places in the text, and the publications are listed hereinafter. Additional definitions and abbreviations can be found in [1] and [2].

[1]   Bluetooth Core Specification, Version 5.2 or later

[2]   Test Strategy and Terminology Overview

[3]   Hearing Access Service, Version 1.0

[4]   ICS Proforma for Hearing Access Service, HAS.ICS

[5]   GATT Test Suite, GATT.TS

[6]   IXIT Proforma for Hearing Access Service

2.2   Definitions

In this Bluetooth document, the definitions from [1] and [2] apply.

2.3   Acronyms and abbreviations

In this Bluetooth document, the definitions, acronyms, and abbreviations from [1] and [2] apply.

3   Test Suite Structure (TSS)

3.1   Overview

The Hearing Access Service requires GAP, GATT, and L2CAP. This is illustrated in Figure 3.1.

Hearing Access Service	
GATT	GAP
ATT (or EATT)	
L2CAP	
Controller	
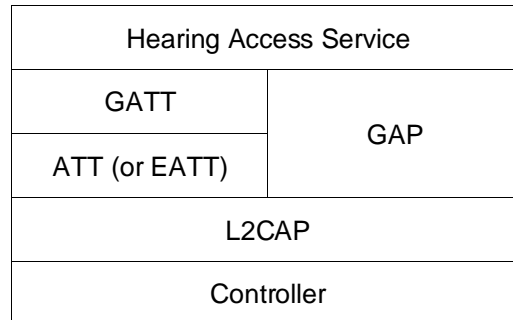
Figure 3.1: Hearing Access Service test model

3.2   Test Strategy

The test objectives are to verify the functionality of the Hearing Access Service within a Bluetooth Host and enable interoperability between Bluetooth Hosts on different devices. The testing approach covers mandatory and optional requirements in the specification and matches these to the support of the IUT as described in the ICS. Any defined test herein is applicable to the IUT if the ICS logical expression defined in the Test Case Mapping Table (TCMT) evaluates to true.

The test equipment provides an implementation of the Radio Controller and the parts of the Host needed to perform the test cases defined in this Test Suite. A Lower Tester acts as the IUT's peer device and interacts with the IUT over-the-air interface. The configuration, including the IUT, needs to implement similar capabilities to communicate with the test equipment. For some test cases, it is necessary to stimulate the IUT from an Upper Tester. In practice, this could be implemented as a special test interface, a Man Machine Interface (MMI), or another interface supported by the IUT.

This Test Suite contains Valid Behavior (BV) tests complemented with Invalid Behavior (BI) tests where required. The test coverage mirrored in the Test Suite Structure is the result of a process that started with catalogued specification requirements that were logically grouped and assessed for testability enabling coverage in defined test purposes.

3.3   Test groups

The following test groups have been defined:

- ATT Configuration

  Verify the configuration of the ATT Server.

- Generic GATT Integrated Tests

  Verify the generic GATT behavior for discovery, characteristics, descriptor, indications, notifications, etc.

- Hearing Aid Preset Control Point Procedures

  Verify the behavior of the procedure triggered by writing the Preset Name and changing Presets by writing to or notifying the Hearing Aid Preset Control Point.

- Service Procedure – Error Handling

    Verify that the IUT correctly handles error conditions that result from the characteristic writes or failure to perform a requested operation due to rejection of the result by a peer device.

- Validation Tests

    Verify the behavior of characteristics.

4   Test cases (TC)

4.1   Introduction

4.1.1   Test case identification conventions

Test cases are assigned unique identifiers per the conventions in [2]. The convention used here is:
<spec abbreviation>/**<IUT role>**/<class>/**<feat>**/<func>/<subfunc>/<cap>/**<xx>-<nn>-<y>**.

Additionally, testing of this specification includes tests from the GATT Test Suite [5] referred to as Generic GATT Integrated Tests (GGIT); when used, the GGIT tests are referred to through a TCID string using the following convention:
<spec abbreviation>/**<IUT role>**/**<GGIT test group>**/< GGIT class >/<xx>-<nn>-<y>.

Identifier Abbreviation	Spec Identifier <spec abbreviation>
HAS	Hearing Access Service
Identifier Abbreviation	Role Identifier <IUT role>
SR	Server
Identifier Abbreviation	Features and Behaviors Identifier <feat>
AI	Active Preset Index
CFG	Server Configuration
CP	Control Point
FEAT	Hearing Access Features
SPE	Service Procedure – Error Handling
VAL	Validation
Identifier Abbreviation	Reference Identifier <GGIT test group>
SGGIT	Server Generic GATT Integrated Tests
Identifier Abbreviation	Reference Identifier <GGIT test group>
CHA	Characteristic GGIT
SER	Service GGIT

Table 4.1: HAS TC feature naming conventions

4.1.2   Conformance

When conformance is claimed for a particular specification, all capabilities are to be supported in the specified manner. The mandated tests from this Test Suite depend on the capabilities to which conformance is claimed.

The Bluetooth Qualification Program may employ tests to verify implementation robustness. The level of implementation robustness that is verified varies from one specification to another and may be revised for cause based on interoperability issues found in the market.

Such tests may verify:

- That claimed capabilities may be used in any order and any number of repetitions not excluded by the specification

- That capabilities enabled by the implementations are sustained over durations expected by the use case

- That the implementation gracefully handles any quantity of data expected by the use case

- That in cases where more than one valid interpretation of the specification exists, the implementation complies with at least one interpretation and gracefully handles other interpretations

- That the implementation is immune to attempted security exploits

A single execution of each of the required tests is required to constitute a Pass verdict. However, it is noted that to provide a foundation for interoperability, it is necessary that a qualified implementation consistently and repeatedly pass any of the applicable tests.

In any case, where a member finds an issue with the test plan generated by Launch Studio, with the test case as described in the Test Suite, or with the test system utilized, the member is required to notify the responsible party via an erratum request such that the issue may be addressed.

4.1.3   Pass/Fail verdict conventions

Each test case has an Expected Outcome section. The IUT is granted the Pass verdict when all the detailed pass criteria conditions within the Expected Outcome section are met.

The convention in this Test Suite is that, unless there is a specific set of fail conditions outlined in the test case, the IUT fails the test case as soon as one of the pass criteria conditions cannot be met. If this occurs, then the outcome of the test is a Fail verdict.

4.2   Setup preambles

The procedures defined in this section are used to achieve specific conditions on the IUT and the test equipment within the tests defined in this document. The preambles here are commonly used to establish initial conditions.

4.2.1   ATT Bearer on LE Transport

- Preamble Procedure

    1. Establish an LE transport connection between the IUT and the Lower Tester.
    2. Establish an L2CAP channel 0x0004 between the IUT and the Lower Tester over that LE transport.

4.2.2   EATT Bearer on LE Transport

- Preamble Procedure

    1. Establish an LE transport connection between the IUT and the Lower Tester.
    2. Establish an L2CAP channel 0x0005 for signaling and one L2CAP channel (for ATT bearers) with EATT PSM (as defined in Assigned Numbers) between the IUT and the Lower Tester over that LE transport.

4.2.3   Hearing Aid Preset Control Point

4.2.3.1   Preset Control Point

- Preamble Purpose

    This preamble procedure enables the IUT for use with the Hearing Aid Preset Control Point.

- Preamble Procedure

    1. Establish an ATT Bearer connection between the Lower Tester and the IUT as described in Section 4.2.1, if using ATT over an LE transport, or Section 4.2.2 if using EATT over an LE transport.

2. The handle of the Hearing Aid Preset Control Point characteristic has been previously discovered by the Lower Tester during a test procedure in Section 4.3 or is known to the Lower Tester by other means.

3. The handle of the Client Configuration descriptor of the Preset characteristic has been previously discovered by the Lower Tester during a test procedure in Section 4.3 or is known to the Lower Tester by other means.

4. If the IUT requires bonding, then the Lower Tester performs a bonding procedure.

5. Enable GATT indications and optionally notifications by performing the preamble in Section 4.2.4.

4.2.4   GATT Notification and Indication

The procedures defined in this section are provided to set up notifications and indications for the EATT or Unenhanced ATT bearers.

4.2.4.1   EATT Bearer, Notifications and Indications

- Preamble Purpose

  This preamble procedure enables the IUT with an EATT Bearer to use indications, and optionally notifications, with the Hearing Aid Preset Control Point.

- Preamble Procedure

  1. The Lower Tester writes the value 0x0002 if indications are supported and notifications are not supported, or 0x0003 if both indications and notifications are supported, using the GATT Write Characteristic Descriptor sub-procedure to the IUT for the Preset Control Point CCCD.

4.2.4.2   Unenhanced ATT Bearer

- Preamble Purpose

  This preamble procedure enables the IUT with an Unenhanced ATT Bearer to use indications with the Hearing Aid Preset Control Point.

- Preamble Procedure

  1. The Lower Tester writes the value 0x0002 using the GATT Write Characteristic Descriptor sub-procedure to the IUT for the Preset Control Point CCCD.

4.3   Generic GATT Integrated Tests

Execute the Generic GATT Integrated Tests defined in Section 6.3, Server test procedures (SGGIT), in [5] using Table 4.2 below as input:

TCID	Service / Characteristic / Descriptor	Reference	Properties	Value Length (Octets)	Type
HAS/SR/SGGIT/SER/BV-01-C [Service GGIT – Hearing Access]	Hearing Access Service	[3] 2	-	-	Primary
HAS/SR/SGGIT/CHA/BV-01-C [Characteristic GGIT – Hearing Aid Preset Control Point, EATT, Indicate]	Hearing Aid Preset Control Point Characteristic	[3] 3.2	Mandatory: 0x28 (Indicate, Write) Optional: 0x10 (Notify)	skip	-
HAS/SR/SGGIT/CHA/BV-02-C [Characteristic GGIT – Hearing Aid Preset Control Point, Unenhanced ATT]	Hearing Aid Preset Control Point Characteristic	[3] 3.2	0x28 (Indicate, Write)	skip	-
HAS/SR/SGGIT/CHA/BV-03-C [Characteristic GGIT – Active Preset Index]	Active Preset Index Characteristic	[3] 3.3	0x12 (Notify, Read)	1	-
HAS/SR/SGGIT/CHA/BV-04-C [Characteristic GGIT – Hearing Aid Features]	Hearing Aid Features Characteristic	[3] 3.1	Mandatory: 0x02 (Read) Optional: 0x10 (Notify)	1	-

Table 4.2: Input for the GGIT Server test procedure

4.4 Server Configuration

Verify the Server Configuration.

HAS/SR/CFG/BV-01-C [Verify the ATT Server MTU Value]

- Test Purpose

  Verify that a HAS Server IUT supports an ATT_MTU value of at least 49.

- Reference

  [3] 1.4

- Initial Condition

  - Establish a Bearer connection between the Lower Tester and the IUT as described in Section 4.2.1 using ATT over an LE transport.

- Test Procedure

  1. The Lower Tester sends an ATT_EXCHANGE_MTU_REQ to the IUT with Client Rx MTU set to 50.
  2. The IUT sends an ATT_EXCHANGE_MTU_RSP to the Lower Tester with Server Rx MTU set >= 49.

- Expected Outcome

  Pass verdict

  In step 2, the IUT sets the Server Rx MTU >= 49.

4.5 Hearing Aid Features

Verify that the Hearing Aid Feature bits in the Hearing Aid Features characteristic are set properly.

4.5.1 Hearing Aid Feature bits

- Test Purpose

  Verify that a HAS Server IUT has the feature bits in the Hearing Aid Feature characteristic properly set.

- Reference

  [3] 3.1

- Initial Condition

  - Establish a Bearer connection between the Lower Tester and the IUT as described in Section 4.2.1, if using ATT over an LE transport, or Section 4.2.2 if using EATT over an LE transport.

  - The IUT has the Hearing Aid Features characteristic set to reflect its capabilities.

- Test Case Configuration

Test Case	Hearing Aid Features bit value
HAS/SR/FEAT/BV-01-C [Hearing Aid Feature bits – Preset Synchronization supported]	Bit 2: 0b1
HAS/SR/FEAT/BV-02-C [Hearing Aid Feature bits – Preset Synchronization not supported]	Bit 2: 0b0
HAS/SR/FEAT/BV-03-C [Hearing Aid Feature bits – Independent Presets supported]	Bit 3: 0b1
HAS/SR/FEAT/BV-04-C [Hearing Aid Feature bits – Independent Presets not supported]	Bit 3: 0b0
HAS/SR/FEAT/BV-05-C [Hearing Aid Feature bits – Dynamic Presets supported]	Bit 4: 0b1
HAS/SR/FEAT/BV-06-C [Hearing Aid Feature bits – Dynamic Presets not supported]	Bit 4: 0b0
HAS/SR/FEAT/BV-07-C [Hearing Aid Feature bits – Writable Presets supported]	Bit 4: 0b1 Bit 5: 0b1
HAS/SR/FEAT/BV-08-C [Hearing Aid Feature bits – Writable Presets not supported]	Bit 5: 0b0

Table 4.3: Hearing Aid Feature bits test cases

- Test Procedure

    1. The Lower Tester executes the GATT Read sub-procedure for the Hearing Aid Features characteristic.
    2. The Lower Tester verifies that the bits in the Hearing Aid Features characteristic are set as specified in Table 4.3.

- Expected Outcome

    <u>Pass verdict</u>

    In step 1, the IUT returns the Hearing Access Features characteristic with the bit and value as specified in Table 4.3.

4.6   Active Preset Index

Verify the Active Preset Index.

HAS/SR/AI/BV-01-C [Active Preset Index Notifications]

- Test Purpose

    Verify that a HAS Server IUT properly updates the Active Preset Index characteristic when the IUT autonomously changes the preset in use.

- Reference

    [3] 3.2

- Initial Condition

    - Establish a Bearer connection between the Lower Tester and the IUT as described in Section 4.2.1, if using ATT over an LE transport, or Section 4.2.2 if using EATT over an LE transport.

- The IUT enables notifications by writing the value 0x0001 using the GATT Write Characteristic Descriptor sub-procedure for the Active Preset Index characteristic.

- The Active Preset Index Characteristic on the IUT is Index 0.

- The list of Preset Record indexes that are Available is defined by the TSPX_available_preset_index IXIT value.

- Test Procedure

  Repeat steps 1–3 for each Preset_Index in TSPX_available_preset_index.

  1. The Upper Tester instructs the IUT to use the preset with Preset_Index.
  2. The IUT sends a GATT Characteristic Value Notification for the Active Preset Index characteristic with the Index set to Preset_Index.
  3. The Lower Tester executes the GATT Read sub-procedure for the Active Preset Index characteristic.

- Expected Outcome

  Pass verdict

  In step 2, the IUT sends an Active Preset Index notification for the Preset_Index.

  In step 3, the IUT returns the Active Preset Index set to Preset_Index.

4.7   Control Point Procedures

Verify Hearing Aid Preset Control Point procedures.

HAS/SR/CP/BV-01-C [Read Presets Request]

- Test Purpose

  Verify that a HAS Server IUT correctly responds to the Read Presets Request procedure for a single record.

- Reference

  [3] 3.2.2.1

- Initial Condition

  - Establish a Bearer connection between the Lower Tester and the IUT as described in Section 4.2.1, if using ATT over an LE transport, or Section 4.2.2 if using EATT over an LE transport.

  - Enable the Hearing Aid Preset Control Point in the IUT by performing the preamble described in Section 4.2.3.

  - The largest of preset index is defined by the TSPX_largest_preset_index IXIT value.

  - The IUT Preset Records with Indicies 1 and TSPX_largest_preset_index have Name set to a UTF-8 encoded string.

  - The number of total presets is defined by the TSPX_num_presets IXIT value.

- Test Procedure

  Repeat steps 1–3 for each round in Table 4.4.

  1. The Lower Tester executes the GATT Write sub-procedure for the Hearing Aid Preset Control Point characteristic with the Read Presets Request Operation with StartIndex and NumPresets set as specified in Table 4.4.
  2. The Lower Tester receives a Write Response indicating that the IUT has accepted the Opcode.
  3. The IUT sends a GATT Characteristic Value Notification or Indication for the Hearing Aid Preset Control Point characteristic to the Lower Tester with Opcode set to "Read Preset Response" with isLast set to 0x01, the Preset record with Index set to the value in step 1, and Properties and Name set to the values for the Preset record.
  4. Repeat step 3 for the Records Returned specified in Table 4.4.

Round	Start Index	Number of Presets	Records Returned
1	1	1	1
2	TSPX_largest_preset_index	1	1
3	1	0xFF	TSPX_num_presets

Table 4.4: Read Presets Request, Single Record rounds

- Expected Outcome

  <u>Pass verdict</u>

  In each round, the IUT sends a notification or indication to the Lower Tester in step 3 with the Preset record with a UTF-8 encoded string for the Index in step 1.

  The last Preset record notification or indication in step 3 has isLast set to 0x01.

HAS/SR/CP/BV-02-C [Preset Changed]

- Test Purpose

  Verify that a HAS Server IUT sends a Preset Changed to the Lower Tester with the changed Preset record.

- Reference

  [3] 3.2.2.2

- Initial Condition

  - Establish a Bearer connection between the Lower Tester and the IUT as described in Section 4.2.1, if using ATT over an LE transport, or Section 4.2.2 if using EATT over an LE transport.

  - Enable the Hearing Aid Preset Control Point in the IUT by performing the preamble described in Section 4.2.3.

  - The list of Preset Record indexes that are Available is defined by the TSPX_available_preset_index IXIT value.

  - The list of Preset Record indexes that are Unavailable is defined by the TSPX_unavailable_preset_index IXIT value.

  - The list of Preset Record indexes that are Writable is defined by the TSPX_writable_preset_index IXIT value.

- Test Procedure

Repeat steps 1–2 for each round in Table 4.5. If the Index specified in Table 4.5 does not exist, then skip the round.

1. The Upper Tester instructs the IUT to perform alternatives 1A, 1B, 1C, 1D, or 1E depending on the change type in Table 4.5.
   Alternative 1A (Add Record):
       1A.1   The Upper Tester adds a new Preset record.
   Alternative 1B (Delete Record):
       1B.1   The Upper Tester removes the Preset record with Index as specified in Table 4.5.
   Alternative 1C (Preset Name Change):
       1C.1   The Upper Tester modifies the Preset record with Index as specified in Table 4.5.
   Alternative 1D (Record Available):
       1D.1   The Upper Tester sets the Preset record with Index as specified in Table 4.5 as available.
   Alternative 1E (Record Unavailable):
       1E.1   The Upper Tester sets the Preset record with Index as specified in Table 4.5 as unavailable.
2. The IUT sends a GATT Characteristic Value Notification or Indication for the Hearing Aid Preset Control Point characteristic to the Lower Tester with Opcode set to "Preset Changed" with additional parameters set as specified in Table 4.5.

Round	Change Type	Preset Record Change Id	Notification Parameters	Index
1	Preset Name Change	Generic Update (0x00)	ChangeId = 0x00 isLast = 0x01 PrevIndex = TSPX_writable_preset_index[0] - 1 PresetRecord with new name	TSPX_writable_preset_index[0]
2	Record Available	Preset Record Available (0x02)	ChangeID = 0x02 isLast = 0x01 Index = TSPX_unavailable_preset_index[0]	TSPX_unavailable_preset_index[0]
3	Record Unavailable	Preset Record Unavailable (0x03)	ChangeID = 0x03 isLast = 0x01 Index = TSPX_available_preset_index[0]	TSPX_available_preset_index[0]
4	Add Record	Generic Update (0x00)	ChangeId = 0x00 isLast = 0x01 PresetRecord = new record	N/A
5	Delete Record	Preset Record Deleted (0x01)	ChangeId = 0x01 isLast = 0x01 Index = TSPX_available_preset_index[0]	TSPX_available_preset_index[0]

Table 4.5: Preset Changed rounds

- Expected Outcome

Pass verdict

In each applicable round, the IUT sends the Preset Changed to the Lower Tester in step 2 with the Notification Parameters specified in Table 4.5.

HAS/SR/CP/BV-03-C [Preset Changed, Offline Behavior]

- Test Purpose

  Verify that a HAS Server IUT sends changed characteristic notifications or indications when the Lower Tester reconnects.

- Reference

  [3] 3.2.2.2

- Initial Condition

  - Establish a Bearer connection between the Lower Tester and the IUT as described in Section 4.2.1, if using ATT over an LE transport, or Section 4.2.2 if using EATT over an LE transport.

  - Enable the Hearing Aid Preset Control Point in the IUT by performing the preamble described in Section 4.2.3.

  - The number of total presets is defined by the TSPX_num_presets IXIT value.

  - The list of Preset Record indexes that are Writable is defined by the TSPX_writable_preset_index IXIT value.

- Test Procedure

  1. The Lower Tester disconnects from the IUT.
  2. The Upper Tester instructs the IUT to change the Preset Name of Index TSPX_writable_preset_index[0] to a random name.
  3. The Upper Tester instructs the IUT to add a new Preset record.
  4. The Upper Tester instructs the IUT to add an additional new Preset record.
  5. The Upper Tester instructs the IUT to set the Active Preset to the record added in step 3.
  6. If there are at least two writable presets in TSPX_writable_preset_index, the Upper Tester instructs the IUT to change the name of index TSPX_writable_preset_index[1] to "New Name item".
  7. The Upper Tester instructs the IUT to remove Preset Record 4.
  8. The Lower Tester and the IUT reconnect.

  Steps 9 and 10 can occur in any order after step 8.

  9. Any time after step 8, the IUT sends a GATT Characteristic Value Notification for the Active Preset Characteristic to the Lower Tester with an Index.
  10. The IUT sends a GATT Characteristic Value Notification or Indication for the Hearing Aid Preset Control Point characteristic to the Lower Tester with Opcode set to Preset Changed, a ChangeId, isLast, and additional parameters specific to the ChangeId.

  Repeat step 10 until the isLast is set to 0x01.

- Expected Outcome

  Pass verdict

  In step 10, the IUT sends indications or notifications in order of increasing index.

  In step 9, the IUT sends an Active Preset Characteristic Notification with an Index.

  The Lower Tester verifies that its preset record cache has record 1, which has the Preset Name as specified in step 2, record 4 was deleted, record 5 has a new Preset Name, has two new records as specified in steps 3 and 4, and that the active preset is the record added in step 3.

HAS/SR/CP/BV-04-C [Write Preset Name]

- Test Purpose

    Verify that a HAS Server IUT responds to setting the Write Preset Name Opcode.

- Reference

    [3] 3.2.2.3

- Initial Condition

    - Establish a Bearer connection between the Lower Tester and the IUT as described in Section 4.2.1, if using ATT over an LE transport, or Section 4.2.2 if using EATT over an LE transport.

    - Enable the Hearing Aid Preset Control Point in the IUT by performing the preamble described in Section 4.2.3.

    - The list of Preset Record indexes that are Writable is defined by the TSPX_writable_preset_index IXIT value.

- Test Procedure

    1. The Lower Tester executes the GATT Write sub-procedure for the Hearing Aid Preset Control Point characteristic with the Write Preset Name Operation with Index set to TSPX_writeable_preset_index[0] and Name set to "New Name 1".
    2. The IUT sends a Write Response to the Lower Tester.
    3. The IUT sends a GATT Characteristic Value Notification or Indication for the Hearing Aid Preset Control Point characteristic to the Lower Tester with Opcode set to "Preset record name changed" with Index set to TSPX_writeable_preset_index[0], and Name set to "New Name 1".

- Expected Outcome

    Pass verdict

    In step 2, the IUT sends a GATT Write Response to the Lower Tester.

    In step 3, the IUT sends a notification or indication to the Lower Tester with Index set to TSPX_writeable_preset_index[0] and Name set to "New Name 1".

4.7.1   Set Active Preset

- Test Purpose

    Verify that a HAS Server IUT responds to setting the Set Active Preset Opcode and updates the Active Preset Index characteristic.

- Initial Condition

    - Establish a Bearer connection between the Lower Tester and the IUT as described in Section 4.2.1, if using ATT over an LE transport, or Section 4.2.2 if using EATT over an LE transport.

    - Enable the Hearing Aid Preset Control Point in the IUT by performing the preamble described in Section 4.2.3.

    - The list of Preset Record indexes that are Available is defined by the TSPX_available_preset_index IXIT value.

    - The Active Preset Index Characteristic on the IUT is set to 0.

- Test Case Configuration

Test Case	Reference	Opcode
HAS/SR/CP/BV-05-C [Set Active Preset]	[3] 3.2.2.4	Set Active Preset
HAS/SR/CP/BV-06-C [Set Active Preset – Synchronized Locally]	[3] 3.2.2.7	Set Active Preset – Synchronized Locally

Table 4.6 : Set Active Preset test cases

- Test Procedure

   1. The Lower Tester executes the GATT Write sub-procedure for the Hearing Aid Preset Control Point characteristic with the Opcode set as specified in Table 4.6 with Index set to TSPX_available_preset_index[0].
   2. The IUT sends a GATT Characteristic Value Notification for the Active Preset Index characteristic to the Lower Tester with Index set to TSPX_available_preset_index[0].
   3. The Lower Tester executes the GATT Write sub-procedure for the Hearing Aid Preset Control Point characteristic with the Read Presets Request Operation with StartIndex set to TSPX_available_preset_index[0] and NumPresets set to 1.
   4. The IUT sends a GATT Characteristic Value Notification or Indication for the Hearing Aid Preset Control Point characteristic to the Lower Tester with Opcode set to "Read Preset Response" with isLast set to 0x01 and the Preset record with Index set to TSPX_available_preset_index[0] and the isAvailable field set to 0b1.

- Expected Outcome

   Pass verdict

   In step 2, the IUT sends a notification to the Lower Tester with Index set to TSPX_available_preset_index[0].

   In step 4, the IUT sends a notification or indication to the Lower Tester with isLast set to 0x01 and the isAvailable field set to 0b1.

4.7.2   Set Next Preset

- Test Purpose

   Verify that a HAS Server IUT responds to setting the Set Next Preset Opcode and updates the Active Preset Index characteristic.

- Initial Condition

   - Establish a Bearer connection between the Lower Tester and the IUT as described in Section 4.2.1, if using ATT over an LE transport, or Section 4.2.2 if using EATT over an LE transport.

   - Enable the Hearing Aid Preset Control Point in the IUT by performing the preamble described in Section 4.2.3.

   - The list of Preset Record indexes that are Available is defined by the TSPX_available_preset_index IXIT value.

   - The Active Preset Index Characteristic on the IUT is Index TSPX_available_preset_index[LAST].

- Test Case Configuration

Test Case	Reference	Opcode
HAS/SR/CP/BV-07-C [Set Next Preset]	[3] 3.2.2.5	Set Next Preset
HAS/SR/CP/BV-08-C [Set Next Preset – Synchronized Locally]	[3] 3.2.2.8	Set Next Preset – Synchronized Locally

Table 4.7 : Set Next Preset test cases

- Test Procedure

    1. The Lower Tester executes the GATT Write sub-procedure for the Hearing Aid Preset Control Point characteristic with the Opcode set as specified in Table 4.7.
    2. The IUT sends a GATT Characteristic Value Notification for the Active Preset Index characteristic to the Lower Tester with Index set to TSPX_available_preset_index[0].

    Repeat steps 3 and 4 for each preset in TSPX_available_preset_index.

    3. The Lower Tester executes the GATT Write sub-procedure for the Hearing Aid Preset Control Point characteristic with the Opcode set as specified in Table 4.7.
    4. The IUT sends a GATT Characteristic Value Notification for the Active Preset Index characteristic to the Lower Tester with Index set to the next index in TSPX_available_preset_index.

- Expected Outcome

    Pass verdict

    In step 2, the IUT notifies the Lower Tester with Index set to the first preset index in TSPX_available_preset_index.

    In step 4, the IUT notifies the Lower Tester with Index set to the next preset index in TSPX_available_preset_index.

4.7.3   Set Previous Preset

- Test Purpose

    Verify that a HAS Server IUT responds to setting the Set Previous Preset Opcode and updates the Active Preset Index characteristic.

- Initial Condition

    - Establish a Bearer connection between the Lower Tester and the IUT as described in Section 4.2.1, if using ATT over an LE transport, or Section 4.2.2 if using EATT over an LE transport.

    - Enable the Hearing Aid Preset Control Point in the IUT by performing the preamble described in Section 4.2.3.

    - The list of Preset Record indexes that are Available is defined by the TSPX_available_preset_index IXIT value.

    - The Active Preset Index Characteristic on the IUT is Index TSPX_available_preset_index[0].

- Test Case Configuration

Test Case	Reference	Opcode
HAS/SR/CP/BV-09-C [Set Previous Preset]	[3] 3.2.2.6	Set Previous Preset
HAS/SR/CP/BV-10-C [Set Previous Preset – Synchronized Locally]	[3] 3.2.2.9	Set Previous Preset – Synchronized Locally

Table 4.8 : Set Previous Preset test cases

- Test Procedure

  1. The Lower Tester executes the GATT Write sub-procedure for the Hearing Aid Preset Control Point characteristic with the Opcode set as specified in Table 4.8.
  2. The IUT sends a GATT Characteristic Value Notification for the Active Preset Index characteristic to the Lower Tester with Index set to TSPX_available_preset_index[LAST].

  Repeat steps 3 and 4 for each preset index in TSPX_available_preset_index.

  3. The Lower Tester executes the GATT Write sub-procedure for the Hearing Aid Preset Control Point characteristic with the Opcode set as specified in Table 4.8.
  4. The IUT sends a GATT Characteristic Value Notification for the Active Preset Index characteristic to the Lower Tester with Index set to the previous Index in TSPX_available_preset_index.

- Expected Outcome

  Pass verdict

  In step 2, the IUT notifies the Lower Tester with Index set to the last preset index in TSPX_available_preset_index.

  In step 4, the IUT notifies the Lower Tester with Index set to the previous preset index in TSPX_available_preset_index.

HAS/SR/CP/BV-11-C [Hearing Aid Preset Notification or Indication, Bearer Terminated]

- Test Purpose

  Verify that a HAS Server IUT does not send queued notifications or indications when the Bearer has been terminated.

- Reference

  [3] 3.2.2.1

- Initial Condition

  - Establish a Bearer connection between the Lower Tester and the IUT as described in Section 4.2.1, if using ATT over an LE transport, or Section 4.2.2 if using EATT over an LE transport.

  - Enable the Hearing Aid Preset Control Point in the IUT by performing the preamble described in Section 4.2.3.

  - The list of Preset Record indexes that are Available is defined by the TSPX_available_preset_index IXIT value.

  - The Active Preset Index Characteristic on the IUT is Index 0.

- Test Procedure

    1. The Lower Tester executes the GATT Write sub-procedure for the Hearing Aid Preset Control Point characteristic with the Read Presets Request Opcode with StartIndex set to TSPX_available_preset_index[0] and Num Preset set to 1.
    2. The Lower Tester immediately terminates the Bearer.
    3. The IUT and the Lower Tester reestablish the same type of Bearer connection used prior to the termination.
    4. The IUT does not send the Write Response and the queued notifications or indications.
    5. The Lower Tester executes the GATT Write sub-procedure for the Hearing Aid Preset Control Point characteristic with the Opcode set as "Set Active Preset" with Index set to TSPX_available_preset_index[1].
    6. The IUT sends a GATT Characteristic Value Notification for the Active Preset Index characteristic to the Lower Tester with Index set to TSPX_available_preset_index[1].

- Expected Outcome

    Pass verdict

    After step 3, the IUT does not send the Write Response and the queued notifications or indications with Opcode "Read Preset Response".

    In step 6, the IUT sends the notification for the Active Preset Index characteristic to the Lower Tester with Index set to TSPX_available_preset_index[1].

4.8   Service Procedure Error Handling

Verify Service Procedure Error Handling.

4.8.1   Invalid Opcode

- Test Purpose

    Verify that a HAS Server IUT responds with an error code when receiving a Hearing Aid Preset Control Point Operation Opcode that is not supported.

- Initial Condition

    - Establish a Bearer connection between the Lower Tester and the IUT as described in Section 4.2.1, if using ATT over an LE transport, or Section 4.2.2 if using EATT over an LE transport.

    - Enable the Hearing Aid Preset Control Point in the IUT by performing the preamble described in Section 4.2.3.

    - The IUT has the initial condition specified in Table 4.9.

- Test Case Configuration

Test Case	Reference	Initial Condition	Opcode (Procedure)	Error Code
HAS/SR/SPE/BI-01-C [Invalid Opcode – Read Preset Response Procedure]	[3] 3.2.2	N/A	0x02 (Read Preset Response)	0x80
HAS/SR/SPE/BI-02-C [Invalid Opcode – Preset Changed Procedure]	[3] 3.2.2.2	N/A	0x03 (Preset Changed Procedure)	0x80

Test Case	Reference	Initial Condition	Opcode (Procedure)	Error Code
HAS/SR/SPE/BI-03-C [Invalid Opcode – Write Preset Name Procedure]	[3] 3.2.2.3	Writeable Presets Support set to 0b0	0x04 (Write Preset Name Procedure)	0x80
HAS/SR/SPE/BI-04-C [Invalid Opcode – Set Active Preset – Synchronized Locally Procedure]	[3] 3.2.2.7	Preset Synchronization Support set to 0b0	0x08 (Set Active Preset – Synchronized Locally Procedure)	0x82
HAS/SR/SPE/BI-05-C [Invalid Opcode – Set Next Preset – Synchronized Locally Procedure]	[3] 3.2.2.8	Preset Synchronization Support set to 0b0	0x09 (Set Next Preset – Synchronized Locally Procedure)	0x82
HAS/SR/SPE/BI-06-C [Invalid Opcode – Set Previous Preset – Synchronized Locally Procedure]	[3] 3.2.2.9	Preset Synchronization Support set to 0b0	0x0A (Set Previous Preset – Synchronized Locally Procedure)	0x82
HAS/SR/SPE/BI-07-C [Invalid Opcode – RFU]	[3] 3.2.2	N/A	0xF0 (N/A)	0x80

Table 4.9 : Invalid Opcode test cases

- Test Procedure

    1. The Lower Tester executes the GATT Write sub-procedure for the Hearing Aid Preset Control Point characteristic with the Opcode specified in Table 4.9.
    2. The IUT sends an ATT Error Response to the Lower Tester with the error code specified in Table 4.9.

- Expected Outcome

    Pass verdict

    In step 2, the IUT returns an error code specified in Table 4.9.

HAS/SR/SPE/BI-08-C [Write Name Not Allowed]

- Test Purpose

    Verify that a HAS Server IUT responds with the error code "Write Name Not Allowed" when receiving a Write Preset Name Opcode for a preset record with its Read-only flag set to 0x00.

- Reference

    [3] 3.2.2.3

- Initial Condition

    - Establish a Bearer connection between the Lower Tester and the IUT as described in Section 4.2.1, if using ATT over an LE transport, or Section 4.2.2 if using EATT over an LE transport.

    - Enable the Hearing Aid Preset Control Point in the IUT by performing the preamble described in Section 4.2.3.

    - The Preset Record index that is Not Writable is defined by the TSPX_unwritable_preset_index IXIT value.

- Test Procedure

  1. The Lower Tester executes the GATT Write sub-procedure for the Hearing Aid Preset Control Point characteristic with the Write Preset Name Operation with Index set to TSPX_unwritable_preset_index and Name set to "New Name 3".
  2. The IUT sends an ATT Error Response to the Lower Tester with the error code Write Name Not Allowed (0x81).

- Expected Outcome

  Pass verdict

  In step 2, the IUT returns a Write Name Not Allowed (0x81) error response.

4.8.2 Index Out of Range

- Test Purpose

  Verify that a HAS Server IUT responds with an error code when receiving an Opcode as specified in Table 4.10 with an Index value referring to a preset record not exposed by the server.

- Initial Condition

  - Establish a Bearer connection between the Lower Tester and the IUT as described in Section 4.2.1, if using ATT over an LE transport, or Section 4.2.2 if using EATT over an LE transport.

  - Enable the Hearing Aid Preset Control Point in the IUT by performing the preamble described in Section 4.2.3.

  - The largest preset index is defined by the TSPX_largest_preset_index IXIT value.

- Test Case Configuration

Test Case	Reference	Opcode	Parameter
HAS/SR/SPE/BI-09-C [Index Out of Range – Write Preset Name]	[3] 3.2.2.3	Write Preset Name	Index = TSPX_largest_preset_index + 1 Name = "New Name 8"
HAS/SR/SPE/BI-10-C [Index Out of Range – Set Active Preset]	[3] 3.2.2.4	Set Active Preset	Index = TSPX_largest_preset_index + 1

Table 4.10: Index Out of Range test cases

- Test Procedure

  1. The Lower Tester executes the GATT Write sub-procedure for the Hearing Aid Preset Control Point characteristic with the Opcode and parameters set as specified in Table 4.10.
  2. The IUT sends an ATT Error Response to the Lower Tester with an error code set to Out of Range (0xFF).

- Expected Outcome

  Pass verdict

  In step 2, the IUT sends an ATT Error Response to the Lower Tester with an error code set to 0xFF.

HAS/SR/SPE/BI-11-C [Preset Operation Not Possible]

- Test Purpose

  Verify that a HAS Server IUT responds with the error code "Preset Operation Not Possible" when receiving a Set Active Preset Opcode for a preset record with the isAvailable bit set to 0b0.

- Reference

  [3] 3.2.2.4

- Initial Condition

  - Establish a Bearer connection between the Lower Tester and the IUT as described in Section 4.2.1, if using ATT over an LE transport, or Section 4.2.2 if using EATT over an LE transport.

  - Enable the Hearing Aid Preset Control Point in the IUT by performing the preamble described in Section 4.2.3.

  - The list of Preset record indexes that are Not Available is defined by the TSPX_unavailable_preset_index IXIT value.

- Test Procedure

  1. The Lower Tester executes the GATT Write sub-procedure for the Hearing Aid Preset Control Point characteristic with the Set Active Preset Opcode with Index set to TSPX_unavailable_preset_index[0].
  2. The IUT sends an ATT Error Response to the Lower Tester with the error code "Preset Operation Not Possible".

- Expected Outcome

  <u>Pass verdict</u>

  In step 2, the IUT returns a "Preset Operation Not Possible" error response.

HAS/SR/SPE/BI-12-C [Write Name, Invalid Length]

- Test Purpose

  Verify that a HAS Server IUT responds with the error code "Invalid Parameters Length" when receiving a Write Preset Name Opcode for a preset record with an invalid length.

- Reference

  [3] 3.2.2.3

- Initial Condition

  - Establish a Bearer connection between the Lower Tester and the IUT as described in Section 4.2.1, if using ATT over an LE transport, or Section 4.2.2 if using EATT over an LE transport.

  - Enable the Hearing Aid Preset Control Point in the IUT by performing the preamble described in Section 4.2.3.

  - The list of Preset Record indexes that are Writable is defined by the TSPX_writable_preset_index IXIT value.

- Test Procedure

  1. The Lower Tester executes the GATT Write sub-procedure for the Hearing Aid Preset Control Point characteristic with the Write Preset Name Operation with Index set to TSPX_writable_preset_index[0] and Name set to a length of 0 octets.
  2. The IUT sends an ATT Error Response to the Lower Tester with the Invalid Parameters Length (0x84) error code.

3. The Lower Tester executes the GATT Write sub-procedure for the Hearing Aid Preset Control Point characteristic with the Write Preset Name Operation with Index set to TSPX_writable_preset_index[0] and Name set to 41 random octets.
4. The IUT sends an ATT Error Response to the Lower Tester with the Invalid Parameters Length (0x84) error code.

- Expected Outcome

   Pass verdict

   In steps 2 and 4, the IUT returns an Invalid Parameters Length (0x84) error response.

HAS/SR/SPE/BI-13-C [Read Presets Request, Invalid Index]

- Test Purpose

   Verify that a HAS Server IUT responds with the error code "Out of Range" when receiving a Read Presets Request procedure with an invalid StartIndex.

- Reference

   [3] 3.2.2.1

- Initial Condition

   - Establish a Bearer connection between the Lower Tester and the IUT as described in Section 4.2.1, if using ATT over an LE transport, or Section 4.2.2 if using EATT over an LE transport.

   - Enable the Hearing Aid Preset Control Point in the IUT by performing the preamble described in Section 4.2.3.

   - The largest preset index is defined by the TSPX_largest_preset_index IXIT value.

   - The IUT Preset Records with Indicies 1 and TSPX_largest_preset_index have Name set to a UTF-8 string.

   - The number of total presets is defined by the TSPX_num_presets IXIT value.

- Test Procedure

   1. The Lower Tester executes the GATT Write sub-procedure for the Hearing Aid Preset Control Point characteristic with the Read Presets Request Operation with StartIndex set to TSPX_largest_preset_index + 1 and NumPresets set to 1.
   2. The IUT sends an ATT Error Response to the Lower Tester with the Out of Range (0xFF) error code.
   3. The Lower Tester executes the GATT Write sub-procedure for the Hearing Aid Preset Control Point characteristic with the Read Presets Request Operation with StartIndex set to 0xFF and NumPresets set to 1.
   4. The IUT sends an ATT Error Response to the Lower Tester with the Out of Range (0xFF) error code.

- Expected Outcome

   Pass verdict

   In steps 2 and 4, the IUT returns an Out of Range error code.

HAS/SR/SPE/BI-14-C [Read Presets Request, No Presets]

- Test Purpose

    Verify that a HAS Server IUT without Preset Records responds with the error code "Out of Range" when receiving a Read Presets Request procedure.

- Reference

    [3] 3.2.2.1

- Initial Condition

    - Establish a Bearer connection between the Lower Tester and the IUT as described in Section 4.2.1, if using ATT over an LE transport, or Section 4.2.2 if using EATT over an LE transport.

    - Enable the Hearing Aid Preset Control Point in the IUT by performing the preamble described in Section 4.2.3.

    - The IUT doesn't have any Preset Records.

- Test Procedure

    1. The Lower Tester executes the GATT Write sub-procedure for the Hearing Aid Preset Control Point characteristic with the Read Presets Request Operation with StartIndex set to 1 and NumPresets set to 1.
    2. The IUT sends an ATT Error Response to the Lower Tester with the Out of Range (0xFF) error code.

- Expected Outcome

    Pass verdict

    In step 2, the IUT returns an Out of Range error code.

5   Test case mapping

The Test Case Mapping Table (TCMT) maps test cases to specific requirements in the ICS. The IUT is tested in all roles for which support is declared in the ICS document.

The columns for the TCMT are defined as follows:

Item: Contains a logical expression based on specific entries from the associated ICS document. Contains a logical expression (using the operators AND, OR, NOT as needed) based on specific entries from the applicable ICS document(s). The entries are in the form of y/x references, where y corresponds to the table number and x corresponds to the feature number as defined in the ICS document for Hearing Access Service [4].

Feature: A brief, informal description of the feature being tested.

Test Case(s): The applicable test case identifiers are required for Bluetooth Qualification if the corresponding y/x references defined in the Item column are supported. Further details about the function of the TCMT are elaborated in [2].

For the purpose and structure of the ICS/IXIT, refer to [2].

Item	Feature	Test Case(s)
HAS 2/2	Hearing Access Service	HAS/SR/SGGIT/SER/BV-01-C HAS/SR/CFG/BV-01-C
HAS 3/1 AND HAS 3/1a	Hearing Aid Preset Control Point, Notifications and EATT supported	HAS/SR/SGGIT/CHA/BV-01-C
HAS 3/1 AND NOT HAS 3/1a	Hearing Aid Preset Control Point, Notifications not supported, only Unenhanced ATT bearer supported	HAS/SR/SGGIT/CHA/BV-02-C
HAS 3/2	Active Preset Index Characteristic	HAS/SR/SGGIT/CHA/BV-03-C HAS/SR/AI/BV-01-C
HAS 3/3	Hearing Aid Features Characteristic	HAS/SR/SGGIT/CHA/BV-04-C
HAS 4/1 AND HAS 4/2	Hearing Aid Preset Control Point, Read Presets Request	HAS/SR/CP/BV-01-C HAS/SR/CP/BV-11-C HAS/SR/SPE/BI-13-C HAS/SR/SPE/BI-14-C
HAS 4/3	Hearing Aid Preset Control Point, Preset Changed Notification	HAS/SR/CP/BV-02-C
HAS 4/3 AND HAS 3/12	Hearing Aid Preset Control Point, Preset Changed Notification, Writable Presets	HAS/SR/CP/BV-03-C
HAS 4/4	Hearing Aid Preset Control Point, Write Preset Name	HAS/SR/SPE/BI-09-C
HAS 4/4 AND HAS 3/13	Hearing Aid Preset Control Point, Write Preset Name, Unwritable Presets	HAS/SR/SPE/BI-08-C
HAS 4/4 AND HAS 3/12	Hearing Aid Preset Control Point, Write Preset Name	HAS/SR/SPE/BI-12-C HAS/SR/CP/BV-04-C
HAS 4/5	Hearing Aid Preset Control Point, Set Active Preset	HAS/SR/CP/BV-05-C HAS/SR/SPE/BI-10-C
HAS 4/5 AND HAS 3/14	Hearing Aid Preset Control Point, Set Active Preset, Not Available Presets	HAS/SR/SPE/BI-11-C

Item	Feature	Test Case(s)
HAS 4/8	Hearing Aid Preset Control Point, Set Active Preset, Synchronized Locally	HAS/SR/CP/BV-06-C
HAS 4/6	Hearing Aid Preset Control Point, Set Next Preset	HAS/SR/CP/BV-07-C
HAS 4/9	Hearing Aid Preset Control Point, Set Next Preset, Synchronized Locally	HAS/SR/CP/BV-08-C
HAS 4/7	Hearing Aid Preset Control Point, Set Previous Preset	HAS/SR/CP/BV-09-C
HAS 4/10	Hearing Aid Preset Control Point, Set Previous Preset, Synchronized Locally	HAS/SR/CP/BV-10-C
HAS 3/5	Preset Synchronization Supported	HAS/SR/FEAT/BV-01-C
HAS 3/3 AND NOT HAS 3/5	Preset Synchronization Not Supported	HAS/SR/FEAT/BV-02-C
HAS 3/8	Independent Presets Supported	HAS/SR/FEAT/BV-03-C
HAS 3/3 AND NOT HAS 3/8	Independent Presets Not Supported	HAS/SR/FEAT/BV-04-C
HAS 3/6	Dynamic Presets Supported	HAS/SR/FEAT/BV-05-C
HAS 3/3 AND NOT HAS 3/6	Dynamic Presets Not Supported	HAS/SR/FEAT/BV-06-C
HAS 3/7	Writable Presets Supported	HAS/SR/FEAT/BV-07-C
HAS 3/3 AND NOT HAS 3/7	Writable Presets Not Supported	HAS/SR/FEAT/BV-08-C
HAS 4/2	Invalid Opcode, Read Preset Response, Preset Changed, RFU	HAS/SR/SPE/BI-01-C HAS/SR/SPE/BI-02-C HAS/SR/SPE/BI-07-C
HAS 3/1 AND NOT HAS 4/4	Invalid Opcode, Write Preset Name	HAS/SR/SPE/BI-03-C
HAS 3/1 AND NOT HAS 4/8	Invalid Opcode, Set Active Preset, Synchronized Locally	HAS/SR/SPE/BI-04-C
HAS 3/1 AND NOT HAS 4/9	Invalid Opcode, Set Next Preset, Synchronized Locally	HAS/SR/SPE/BI-05-C
HAS 3/1 AND NOT HAS 4/10	Invalid Opcode, Set Previous Preset, Synchronized Locally	HAS/SR/SPE/BI-06-C

Table 5.1: Test case mapping

6   Revision history and acknowledgments

Revision History

Publication Number	Revision Number	Date	Comments
0	p0	2022-06-14	HAS v1.0 adopted by the BoD on 2022-06-07. Prepared for initial publication.
	p1r00–r01	2022-09-01 – 2022-11-03	TSE 19277 (rating 2): Added test procedure instructions between test steps for HAS/SR/CP/BV-03-C, updated test step wording for HAS/SR/CP/BV-07-C – -10-C, and updated test step and pass verdict wording for HAS/SR/CP/BV-05-C, -06-C, and -11-C. TSE 20356 (rating 1): Updated the test purpose for HAS/SR/SPE/BI-12-C. TSE 20393 (rating 2): Corrected rounds table for HAS/SR/CP/BV-02-C. Template-related editorials.
1	p1	2023-02-07	Approved by BTI on 2022-12-19. Prepared for TCRL 2022-2 publication.
	p1ed2r00–r01	2023-03-10 – 2023-04-13	TSE 19137 (rating 1): Updated the initial condition and pass verdict in HAS/SR/CP/BV-01-C.
	p1 edition 2	2023-04-14	Approved by BTI on 2023-04-13. Prepared for edition 2 publication.

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