Published Audio Capabilities Service (PACS)

***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 Published Audio Capabilities Service (PACS) specification 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] Published Audio Capabilities Service (PACS), Version 1.0

[4] ICS Proforma for Published Audio Capabilities Service (PACS)

[5] Characteristic and Descriptor descriptions are accessible via the Bluetooth SIG Assigned Numbers

[6] GATT Test Suite, GATT.TS

3 Test Suite Structure (TSS)

3.1 Test Strategy

The Published Audio Capabilities Service exposes Published Audio Capabilities (PAC) records.

The Published Audio Capabilities Service requires the presence of GAP, SM (when used over LE transport), SDP (when used over BR/EDR transport), L2CAP, and GATT over ATT. EATT can optionally be used. This is illustrated in Figure 3.1.

<table>
<tr><td colspan="4">Published Audio Capabilities Service</td></tr>
<tr><td colspan="4">GATT</td></tr>
<tr><td>ATT
(or EATT)</td><td>GAP</td><td>SM
(LE)</td><td>SDP
(BR/EDR)</td></tr>
<tr><td colspan="4">L2CAP</td></tr>
<tr><td colspan="4">Controller</td></tr>
</table>

Figure 3.1: Published Audio Capabilities Service test model

The test objectives are to verify the functionality of the Published Audio Capabilities 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.

The 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 cataloged specification requirements that were logically grouped and assessed for testability enabling coverage in defined test purposes.

The Test Suite supports the IUT in the Server role and the Lower Tester in the Client role.

3.2 Test groups

The following test groups have been defined:

- Generic GATT Integrated Tests
- Validation
- PACS Characteristics Update

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 [6] 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>**
PACS	Published Audio Capabilities Service
Identifier Abbreviation	**Role Identifier <IUT role>**
SR	Server
Identifier Abbreviation	**Feature Identifier <feat>**
PCU	PACS Characteristic Update
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 class>**
CHA	Characteristic GGIT
SDP	SDP GGIT
SER	Service GGIT

Table 4.1: PACS 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 the Bluetooth SIG qualification tool, 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, the outcome of the test is a Fail verdict.

4.2 Setup preambles

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 ATT Bearer on BR/EDR Transport

- Preamble Procedure

1. Establish a BR/EDR transport connection between the IUT and the Lower Tester.
2. Establish an L2CAP channel (PSM 0x001F) between the IUT and the Lower Tester over that BR/EDR transport.

4.2.3 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 or more L2CAP channels (for ATT bearers) with EATT PSM (as defined in Assigned Numbers) between the IUT and the Lower Tester over that LE transport.

4.2.4 EATT Bearer on BR/EDR Transport

- Preamble Procedure

1. Establish a BR/EDR transport connection between the IUT and the Lower Tester.
2. Establish an L2CAP channel 0x0001 for signaling and one or more L2CAP channels (for ATT bearers) with EATT PSM (as defined in Assigned Numbers) between the IUT and the Lower Tester over that BR/EDR transport.

4.3 Generic GATT Integrated Tests

Execute the Generic GATT Integrated Tests defined in Section 6.3, Server test procedures (SGGIT), in [6] using Table 4.2 below as input:

TCID	Service / Characteristic / Descriptor	Reference	Properties	Value Length (Octets)	Type
PACS/SR/SGGIT/SER/BV-01-C [Service GGIT – Published Audio Capabilities]	Published Audio Capabilities Service	[3] 2	-	-	Unique
PACS/SR/SGGIT/CHA/BV-01-C [Characteristic GGIT – Sink PAC]	Sink PAC	[3] 3.1.1	Mandatory: 0x02 (Read) Optional: 0x10 (Notify)	Skip	-
PACS/SR/SGGIT/CHA/BV-02-C [Characteristic GGIT – Sink Audio Locations]	Sink Audio Locations	[3] 3.2.1	Mandatory: 0x02 (Read) Optional: 0x18 (Write, Notify)	4	Unique
PACS/SR/SGGIT/CHA/BV-03-C [Characteristic GGIT – Source PAC]	Source PAC	[3] 3.3.1	Mandatory: 0x02 (Read) Optional: 0x10 (Notify)	Skip	-
PACS/SR/SGGIT/CHA/BV-04-C [Characteristic GGIT – Source Audio Locations]	Source Audio Locations	[3] 3.4.1	Mandatory: 0x02 (Read) Optional: 0x18 (Write, Notify)	4	Unique
PACS/SR/SGGIT/CHA/BV-05-C [Characteristic GGIT – Available Audio Contexts]	Available Audio Contexts	[3] 3.5.1	0x12 (Read, Notify)	4	Unique
PACS/SR/SGGIT/CHA/BV-06-C [Characteristic GGIT – Supported Audio Contexts]	Supported Audio Contexts	[3] 3.6.1	Mandatory: 0x02 (Read) Optional: 0x10 (Notify)	4	Unique
PACS/SR/SGGIT/SDP/BV-01-C [SDP Record]	Published Audio Capabilities Service	[3] 4	-	-	

Table 4.2: Input for the GGIT Server test procedure

4.4 Service procedures

PACS/SR/VAL/BV-01-C [Validate Audio Contexts]

- Test Purpose

  Verify that the Server IUT exposed Available Audio Contexts are a subset of the Supported Audio Contexts characteristic value.

- Reference

  [3] 3.5.1, 3.6.1

- Initial Condition

  - A bearer connection is established between the Lower Tester and the IUT as described in Section 4.2.1, if using ATT over an LE transport, or 4.2.2 if using ATT over a BR/EDR transport, or 4.2.3 if using EATT over an LE transport, or 4.2.4 if using EATT over a BR/EDR transport.
  - The Lower Tester has cached the PAC service and characteristics handles (e.g., by running the procedures in Section 4.3).
  - If the IUT requires bonding, then the Lower Tester performs a bonding procedure.

- Test Procedure

  1. The Lower Tester executes the GATT Read Characteristic Value sub-procedure for the Available Audio Contexts Characteristic.
  2. The Lower Tester executes the GATT Read Characteristic Value sub-procedure for the Supported Audio Contexts Characteristic.

- Expected Outcome

  Pass verdict

  All the bits set in the Available Audio Contexts value are also set in the Supported Audio Contexts value.

  Verify that the Supported_Sink_Contexts and Supported_Source_Contexts field values are valid for the Sink PAC and Source PAC characteristics indicated as supported in the ICS [4].

4.4.1 Update PAC Characteristics – Connected Client

- Test Purpose

  This test group verifies the behavior of the PACS Server IUT when it updates its characteristics while a Client is connected.

- Reference

  [3] 3

- Initial Condition
  - A bearer connection is established between the Lower Tester and the IUT as described in Section 4.2.1, if using ATT over an LE transport, or 4.2.2 if using ATT over a BR/EDR transport, or 4.2.3 if using EATT over an LE transport, or 4.2.4 if using EATT over a BR/EDR transport.
  - The Lower Tester has cached the PAC service and characteristics handles (e.g., by running the procedures in Section 4.3).
  - The Lower Tester enables notification for the characteristic in Table 4.3 by writing the value 0x0001 to the CCCD associated with the specified characteristic using the GATT Write Characteristic Descriptor sub-procedure.
- Test Case Configuration

Test Case	Characteristic UUID	Command
PACS/SR/PCU/BV-01-C [Update Sink PAC – Connected Client]	<< Sink PAC >>	The Upper Tester commands the IUT to update the characteristic read in step 1 with different data.
PACS/SR/PCU/BV-02-C [Update Source PAC – Connected Client]	<< Source PAC >>	The Upper Tester commands the IUT to update the characteristic read in step 1 with different data.
PACS/SR/PCU/BV-03-C [Update Sink Audio Locations – Connected Client]	<< Sink Audio Locations >>	The Upper Tester commands the IUT to update the characteristic read in step 1 with different data.
PACS/SR/PCU/BV-04-C [Update Writable Sink Audio Locations – Connected Client]	<< Sink Audio Locations >>	The Lower Tester executes the GATT Write Characteristic Value sub-procedure with different data.
PACS/SR/PCU/BV-05-C [Update Source Audio Locations – Connected Client]	<< Source Audio Locations >>	The Upper Tester commands the IUT to update the characteristic read in step 1 with different data.
PACS/SR/PCU/BV-06-C [Update Writable Source Audio Locations – Connected Client]	<< Source Audio Locations >>	The Lower Tester executes the GATT Write Characteristic Value sub-procedure with different data.
PACS/SR/PCU/BV-07-C [Update Available Audio Contexts – Connected Client]	<< Available Audio Contexts >>	The Upper Tester commands the IUT to update the characteristic read in step 1 with different data.
PACS/SR/PCU/BV-08-C [Update Supported Audio Contexts – Connected Client]	<< Supported Audio Contexts >>	The Upper Tester commands the IUT to update the characteristic read in step 1 with different data.

Table 4.3: Update PAC Characteristics – Connected Client test cases

- Test Procedure

  1. The Lower Tester reads the characteristic value for the characteristic specified by the Characteristic UUID referenced in Table 4.3 by executing the GATT Read Characteristic Value sub-procedure. If multiple characteristic instances are found, the Lower Tester randomly selects one.
  2. Execute the Command specified in Table 4.3.
  3. The IUT sends a notification containing the updated value of the characteristic as specified in Table 4.3.

- Expected Outcome

  Pass verdict

  In step 1, the characteristic value is correctly formatted and contains either valid PAC records, Audio Locations, or audio Context Types as specified in Table 4.3.

  In step 3, the characteristic value is correctly formatted and is different from the one received in step 1.

4.4.2 Update PACS Characteristics – Bonded Client

- Test Purpose

  This test group verifies the behavior of the PACS Server IUT when it updates the PAC Characteristics while a bonded Client is not connected.

- Reference

  [3] 3

- Initial Condition

  - A bearer connection is established between the Lower Tester and the IUT as described in Section 4.2.1, if using ATT over an LE transport, or 4.2.2 if using ATT over a BR/EDR transport, or 4.2.3 if using EATT over an LE transport, or 4.2.4 if using EATT over a BR/EDR transport.
  - The Lower Tester has cached the PAC service and characteristics handles (e.g., by running the procedures in Section 4.3).
  - The Lower Tester enables notification for the characteristics in Table 4.4 by writing the value 0x0001 using the GATT Write Characteristic Descriptor sub-procedure.
  - The Lower Tester and the IUT have completed a bonding procedure.

- Test Case Configuration

Test Case	Characteristic UUID
PACS/SR/PCU/BV-09-C [Update Sink PAC – Bonded Client]	<< Sink PAC >>
PACS/SR/PCU/BV-10-C [Update Source PAC – Bonded Client]	<< Source PAC >>
PACS/SR/PCU/BV-11-C [Update Sink Audio Locations – Bonded Client]	<< Sink Audio Locations >>
PACS/SR/PCU/BV-12-C [Update Source Audio Locations – Bonded Client]	<< Source Audio Locations >>
PACS/SR/PCU/BV-13-C [Update Available Audio Contexts – Bonded Client]	<< Available Audio Contexts >>
PACS/SR/PCU/BV-14-C [Update Supported Audio Contexts – Bonded Client]	<< Supported Audio Contexts >>

Table 4.4: Update PAC Characteristics – Bonded Client test cases

- Test Procedure

1. The Lower Tester reads and caches the characteristic value for the characteristic indicated in Table 4.4 by executing the GATT Read Characteristic Value sub-procedure. If multiple characteristic instances are found, the Lower Tester randomly selects one.
2. The Lower Tester disconnects from the IUT.
3. The Upper Tester commands the IUT to update the characteristic read in step 1 and to enter connectable mode. If multiple instances were found in step 1, the Upper Tester updates the characteristic randomly selected by the Lower Tester.
4. The Lower Tester re-establishes a bearer connection with the IUT.
5. The IUT sends a notification containing the updated value of the specified characteristic as read in step 3.

- Expected Outcome

Pass verdict

In step 1, the characteristic value is correctly formatted and contains valid PAC records, Audio Locations, or Audio Contexts as specified in Table 4.4.

In step 5, the notified characteristic value is correctly formatted; contains valid PAC records, Audio Locations, or Audio Contexts as specified in Table 4.4; and is different from the one received in step 1.

4.5 Service Procedure – Error Handling

4.5.1 Ignore Invalid Values

- Test Purpose

Verify that the IUT responds with an error when an invalid value is written to a characteristic.

- Reference

[3] 3.2.1, 3.4.1

- Initial Condition
  - A bearer connection is established between the Lower Tester and the IUT as described in Section 4.2.1, if using ATT over an LE transport, or 4.2.2 if using ATT over a BR/EDR transport, or 4.2.3 if using EATT over an LE transport, or 4.2.4 if using EATT over a BR/EDR transport.
  - The Lower Tester has cached the PAC service and characteristics handles (e.g., by running the procedures in Section 4.3).
  - If the IUT requires bonding, then the Lower Tester performs a bonding procedure.
- Test Procedure

  1. The Lower Tester executes the GATT Write Characteristic Value sub-procedure for the Characteristic as specified in Table 4.5 with a different value and some RFU bits set.
  2. The IUT sends an Error Response.
  3. The Lower Tester executes the GATT Write Characteristic Value sub-procedure for the Characteristic as specified in Table 4.5 with a length not equal to 4 octets.
  4. The IUT sends an Error Response.
- Test Case Configuration

Test Case	Characteristic UUID
PACS/SR/SPE/BI-01-C [Ignore Invalid Sink Audio Locations]	<< Sink Audio Locations >>
PACS/SR/SPE/BI-02-C [Ignore Invalid Source Audio Locations]	<< Source Audio Locations >>

Table 4.5: Ignore Invalid Values test cases

- Expected Outcome

  Pass verdict

  The IUT sends an Error Response with the Error Code of Write Request Rejected in steps 2 and 4.

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 Published Audio Capabilities 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.

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

Item	Feature	Test Case(s)
PACS 2/1	Service Supported over BR/EDR	PACS/SR/SGGIT/SDP/BV-01-C
PACS 2/1 OR PACS 2/2	Published Audio Capabilities Service	PACS/SR/SGGIT/SER/BV-01-C
PACS 3/1	Sink PAC Characteristic	PACS/SR/SGGIT/CHA/BV-01-C
PACS 3/2	Sink Audio Locations Characteristic	PACS/SR/SGGIT/CHA/BV-02-C
PACS 3/3	Source PAC Characteristic	PACS/SR/SGGIT/CHA/BV-03-C
PACS 3/4	Source Audio Locations Characteristic	PACS/SR/SGGIT/CHA/BV-04-C
PACS 3/5	Available Audio Contexts Characteristic	PACS/SR/SGGIT/CHA/BV-05-C
PACS 3/6	Supported Audio Contexts Characteristic	PACS/SR/SGGIT/CHA/BV-06-C
PACS 3/5 AND PACS 3/6	Valid Audio Context	PACS/SR/VAL/BV-01-C
PACS 4/2	Notifiable Sink PAC Characteristic	PACS/SR/PCU/BV-01-C
PACS 4/4	Autonomous Sink Audio Locations Notifications	PACS/SR/PCU/BV-03-C
PACS 4/5	Writable Sink Audio Locations Characteristic	PACS/SR/SPE/BI-01-C PACS/SR/PCU/BV-04-C
PACS 4/8	Notifiable Source PAC Characteristic	PACS/SR/PCU/BV-02-C
PACS 4/12	Autonomous Source Audio Locations Notifications	PACS/SR/PCU/BV-05-C
PACS 4/11	Writable Source Audio Locations Characteristic	PACS/SR/SPE/BI-02-C PACS/SR/PCU/BV-06-C
PACS 4/14	Notifiable Available Audio Contexts Characteristic	PACS/SR/PCU/BV-07-C
PACS 4/16	Notifiable Supported Audio Contexts Characteristic	PACS/SR/PCU/BV-08-C
PACS 4/2 AND (PACS 5/1 OR PACS 5/2)	Notifiable Sink PAC Characteristic – Bonded Client	PACS/SR/PCU/BV-09-C

Item	Feature	Test Case(s)
PACS 4/4 AND (PACS 5/1 OR PACS 5/2)	Autonomous Sink Audio Locations Notifications – Bonded Client	PACS/SR/PCU/BV-11-C
PACS 4/8 AND (PACS 5/1 OR PACS 5/2)	Notifiable Source PAC Characteristic – Bonded Client	PACS/SR/PCU/BV-10-C
PACS 4/12 AND (PACS 5/1 OR PACS 5/2)	Autonomous Source Audio Locations Notifications – Bonded Client	PACS/SR/PCU/BV-12-C
PACS 4/14 AND (PACS 5/1 OR PACS 5/2)	Notifiable Available Audio Contexts Characteristic – Bonded Client	PACS/SR/PCU/BV-13-C
PACS 4/16 AND (PACS 5/1 OR PACS 5/2)	Notifiable Supported Audio Contexts Characteristic – Bonded Client	PACS/SR/PCU/BV-14-C

Table 5.1: Test case mapping

6 Revision history and acknowledgments

Revision History

Publication Number	Revision Number	Date	Comments
0	p0	2021-09-21	Approved by BTI on 2021-08-19. Published Audio Capabilities Service (PACS) v1.0 adopted by the BoD on 2021-09-14. Prepared for initial publication.
	p1r00–r01	2023-05-22 – 2023-11-06	TSE 23130 (rating 2): Per EE 22952, updated the test procedure for PACS/SR/SPE/BI-01-C and -02-C to remove the steps checking that the Audio Locations of 0 are rejected, and updated test steps cited in the expected outcome accordingly. Performed editorials to align the document with the latest TS template, including updates to the scope, references, Test Strategy, test case identification conventions, conformance, and TCMT introductory text. Updated the copyright page to align with the latest DNMD. Deleted draft revision history comments prior to p0.
1	p1	2023-12-20	Approved by BTI on 2023-11-22. EE 22952 adopted by the BoD on 2023-12-19. Prepared for TCRL 2023-1-addition publication.
	p2r00	2024-08-14	TSE 24715 (rating 2): Per E19232, updated the pass verdict for test case PACS/SR/VAL/BV-01-C.
2	p2	2024-10-08	Approved by BTI on 2024-09-11. PACS v1.0.2 adopted by the BoD on 2024-10-01. Prepared for TCRL 2024-2-addition publication.

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