Smart Ticketing Alliance - Certification Working Group

STA Contactless Interface Certification for Public Transport Products Technical Guidelines

REVISION LIST

Version	Date	Modifications
V1.0	04/07/2106	First public version
V1.1	20/10/2016	Update following first round robin tests results
V1.2	14/06/2017	Version applicable for PCD and PICC testing in accordance with CEN/TS 16794:2015
V1.3	13/12/2017	Updated for PCDs which do not support transactions with more than one PICC in the reader field
V1.4	05/07/2018	Updated after detection of some errors in Annex C and in G.3
V2.0	06/07/2018	Version applicable for PCD and PICC testing in accordance with CEN/TS 16794:2017
V2.1	16/11/2018	Version applicable for PCD and PICC testing in accordance with CEN/TS 16794:2017 Updated for PCD testing
V2.2	27/11/2020	Clarifications about PICC or PCD erratic behaviours in 3.2 Annex G updated for a test case
V2.3	23/11/2022	Clarifications about PICC re-certification process in case of “Type of card body structure change”
V2.4	12/12/2023	Document updated to permit exceptionally the testing for PCD for which not all the Analog tests can be executed with the final hardware (at the end of 3.2)
V3.0	17/11/2022	Version applicable for PCD and PICC testing in accordance with ISO/IEC TS 24192:2021 Release Candidate version subject to adjustments post round robin tests campaign with accredited Test Laboratories
V3.1	09/07/2024	Update of the table about re-certification following a mono component product change (5.1) Update of the certification upgrade process (5.2) Update of Annex G for PICC and PCD test cases Editorial changes

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Acronyms

APDU	Application Protocol Data Unit
CB	Certification Body
CLF	Contactless Front-end
CWG	Certification Working Group
DUT	Device Under Test
ICS	Implementation Conformance Statement
PCD	Proximity Coupling Device
PICC	Proximity Integrated Circuit Card
RF	Radio Frequency
STA	Smart Ticketing Alliance
UICC	Universal Integrated Circuit Card

Terms and Definition

Certification Body: Third-party entity, member of the STA or sponsored by a STA member, in charge of the certification process as described in the ISO 17065.

Implementation Conformance Statement: Document used for detailed identification of a product or system.

Mono component product: Single component device which encompasses both the contactless communication layers and the ticketing application in the same component.

Multi component product: Multiple component device having at least one component hosting the ticketing application and one component providing the contactless communication capabilities.

Product: Product, system or solution for which the certification of compliance with the Standard is requested.

Reference PICC: Reference PICC (test card) as defined in test method ISO/IEC 10373-6.

Test commands: List of APDU commands and responses used for testing a PICC or a PCD.

Test Laboratory (or Test Lab): Entity performing the evaluation of a product.

Test report: Result of the product or system evaluation process performed by the Test Laboratory.

Test results: Set of measurements produced by the Test Laboratory after product testing.

Test tools: Set of test apparatus and test circuits used for testing the contactless communication of products.

Vendor: Provider of the product which is candidate for certification.

1 Objectives of this Document

This document defines the technical guidelines for testing contactless communication between Public Transport readers and Public Transport objects hosting a transport ticketing application in accordance with the Smart Ticketing Alliance (STA) certification process.

The present document applies to the **Evaluation / Test** step (referenced 3 in Figure 1) and performed by Test Laboratories**.**

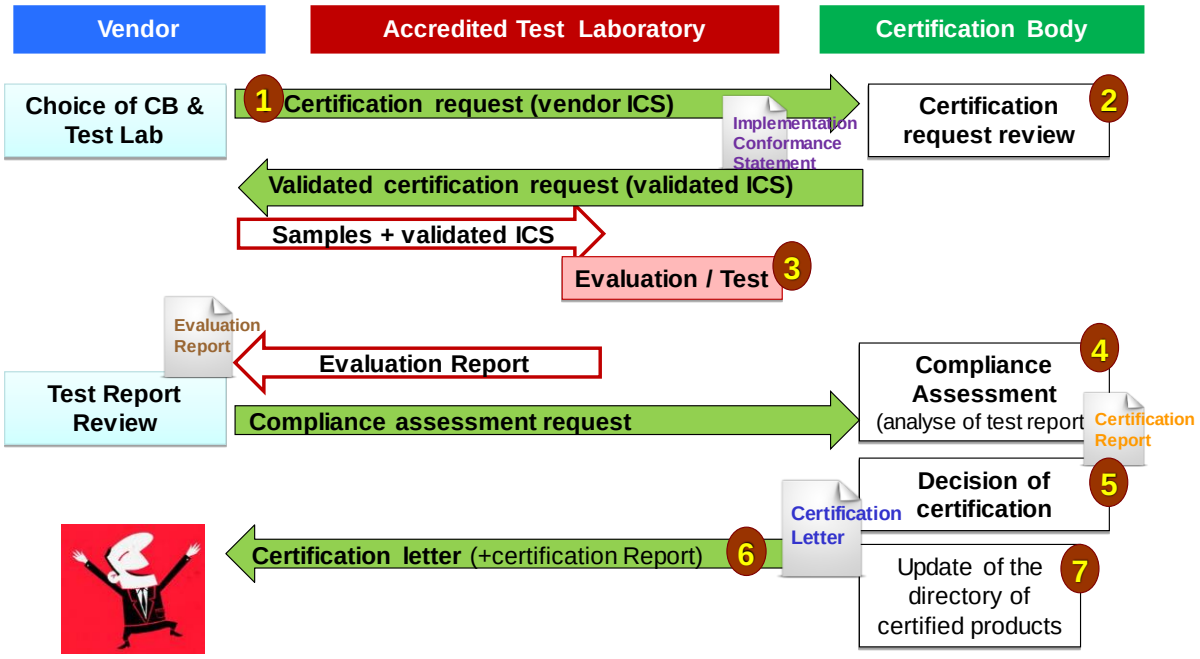


Figure 1 Steps of a STA Certification Process

2 References

The following documents, in whole or in part, are referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendment) applies.

The STA documents are available in the STA repository (www.smart-ticketing.org).

[REF1] ISO/IEC TS 24192-1:2021, Cards and security devices for personal identification — Communication between contactless readers and fare media used in public transport — Part 1: Implementation requirements for ISO/IEC 14443 (all parts)

[REF2] ISO/IEC TS 24192-2:2021, Cards and security devices for personal identification — Communication between contactless readers and fare media used in public transport — Part 2: Test plan for ISO/IEC 14443 (all parts)

[REF3] STA Contactless Interface Certification for Public Transport Products - Test Tools Validation Methodology v3.0

[REF4] STA Contactless Interface Certification for Public Transport Products - Implementation Conformance Statement (ICS) for PICC v3.0

[REF5] STA Contactless Interface Certification for Public Transport Products - Implementation Conformance Statement (ICS) for PCD v3.0

[REF6] GSMA - NFC Handset Requirements - Version 12.0 - 04 December 2017

[REF7] ISO/IEC 10373-6:2020, Cards and security devices for personal identification — Test methods — Part 6: Contactless proximity objects (and AMENDMENT 2: Enhancements for harmonization)

3 What's New in Version 3.0?

This 3rd version of the STA Technical Guidelines document is a continuation of the previous versions. Indeed, as shown in Figure 2, the STA process follows the development of technical specifications for ISO/IEC 14443-conformant PT devices:

- Within CEN TC278 WG3 (Public Transport) with CEN/TS 16794,
- Moved since 2018, within ISO/IEC JTC1/SC17/WG8 (Integrated circuit cards without contacts) with ISO/IEC TS 24192.

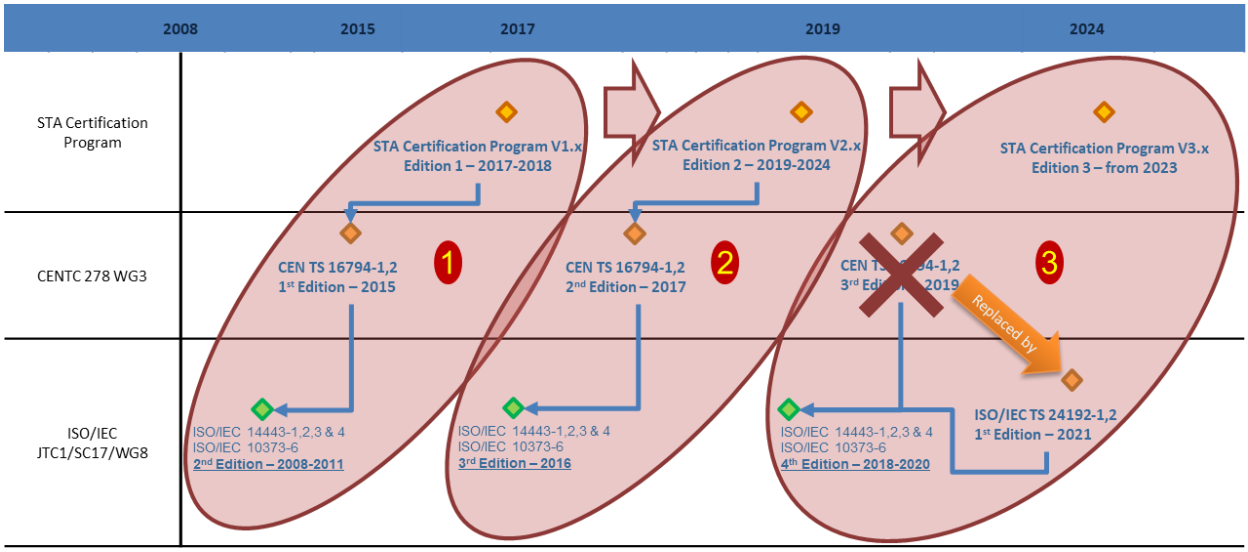


Figure 2 Moving from CEN/TS 16794 to ISO/IEC TS 24192

There is no loss of compatibility: PT devices certified with edition 1 or edition 2 processes will be compatible with PT devices certified with edition 3.

4 General Description of the Evaluation/Test process

The present document aims at defining the technical inputs and outputs that shall be handled by the Test Laboratory for the Evaluation/Test process. It also specifies how the test parameters used for performing the tests are defined.

4.1 Receiving Samples and ICS

At the beginning of the Evaluation/Test step, the Test Laboratory chosen for performing product testing shall receive from the vendor the following items:

- identical samples of the product to be tested,
- the Information Conformance Statement (ICS) form, which lists the characteristics of the product to be tested and the test commands and sequence to be used to run the tests.

For PICC testing:

- the vendor shall provide the Test Laboratory with 10 identical samples of the PICC under test,
- the STA Implementation Conformance Statement for PICC [REF4] available for download from STA website shall be used.

For PCD testing:

- the vendor shall provide the Test Laboratory with 1 sample of the PCD under test,
- the STA Implementation Conformance Statement for PCD [REF5] available for download from STA website shall be used.

The ICS contents shall be validated by the Certification Body.

4.2 Performing the Evaluation/Test

For PICC testing, 9 identical samples shall be picked up by the Test Laboratory from the provided batch of samples:

- 6 identical samples shall be used for the Analog tests, which will be run:
  - on 3 samples for alternating magnetic test,
  - on 3 other samples for all other Analog tests.
- 3 identical samples shall be used for the Digital tests, which will be run:
  - on 3 samples for timing tests ([REF7], G.1.7.1),
  - on 1 sample for all other tests.

The test shall be performed on the samples in accordance with the test plan procedure specified in the ISO/IEC TS 24192-2:2021 test plan [REF2] and with the corrigendum specified in Annex G of this document.

The Test Laboratory shall use test tools validated in a prior step in accordance with the process described in the STA Test Tools Validation Methodology [REF3].

The lists of tests to be performed - extracted from the ISO/IEC TS 24192-2:2021 test plan [REF2] - are described in the annexes:

- the list of Analog tests applicable for PCD product under test is detailed in Annex C,
- the list of Analog tests applicable for PICC product under test is detailed in Annex D,
- the list of Digital tests applicable for PCD product under test is detailed in Annex E,
- the list of Digital tests applicable for PICC product under test is detailed in Annex F.

Based on the characteristics defined in the ICS, the Test Laboratory shall determine which tests of the test plan described in the annexes are applicable.

The Analog tests shall be performed before the Digital tests on the product under test.

Additionally, according to the form factor of the product to be tested, different testing processes may be undertaken:

a) **Mono Component Product:**
The product is a single component device which encompasses both the contactless communication layers and the ticketing application in the same component. The product is then tested as a whole.

Examples: all types of readers & smart cards with a contactless interface…

In this case, all the characteristics of the products shall be indicated in the ICS by the vendor.

The Test Laboratory shall run a test campaign with the DUT and execute the tests which are relevant according to the ICS information.

b) **Multi Component Product:**
The product is a multi-component device requiring more than one component for correct operation:

- the DUT is the device containing the communication contactless layers,
- but the ticketing application is hosted in a separate component.

For these products, some characteristics may be dependent on the component hosting the ticketing application.

Examples: UICC-based NFC handheld inspection terminals or USB tokens may have the ticketing application hosted on removable secure element, which is the UICC.

The present document addresses for the time being only the following cases for multi component products:

- UICC-based NFC handheld terminals,
- UICC-based USB NFC tokens.

Further configurations may be added in the future.

UICC-Based NFC Handheld Terminals/ UICC-Based USB NFC Tokens

For these products, a set of 5 Reference UICC are provided to the Test Laboratory by the STA CWG for performing the testing. Each Reference UICC is configured with different characteristics to be able to test the product in the widest possible situations. Their UICC characteristics (or UICC profiles) are defined in Annex A.

The vendor shall only indicate in the ICS all the characteristics which are related to the product and not dependent on the component hosting the application.

The Test Laboratory shall run one test campaign per DUT / Reference UICC combination and execute the tests which are relevant according to the ICS information. A separate test report will be produced for each DUT/ Reference UICC combination.

NOTE According to the supported types (A, B or A&B), the 5 Reference UICCs may not all necessarily be used for the test campaign.

Additionally, when the DUT is a battery powered PICC, some additional tests may be performed:

Battery Powered PICC

Battery powered PICC will be tested in 2 modes:

- in nominal mode, **with** the battery fully charged;
- in "battery low" mode, as defined in the GSMA - NFC Handset Requirements [REF6].

The Test Laboratory shall run a test campaign with the DUT in nominal mode and execute all the applicable tests based on the ICS information.

An additional test campaign shall be executed with the product in “battery low” mode if, and only if, the vendor has provided the Test Laboratory with an environment allowing it to operate continuously with the DUT in “battery low” mode. For instance, this can be a battery providing a voltage corresponding to the “battery low” mode definition.

The list of tests to be performed in “battery low” mode is listed in Annex B.

If no battery low mode environment is provided by the vendor, no test will be performed in “battery low” mode.

The lists of tests to be performed in nominal mode are listed in Annex D for PICC Analog tests and in Annex F for PICC Digital tests.

Tests on PCD need to be performed in final configuration, that is:

- whole test software installed,
- final hardware configuration: with cover, accessories, etc. which could have an impact on RF behaviour.

In case of a PCD for which not all the Analog tests can be executed (ex: casing volume not adapted to the climatic chamber, testing positions not accessible by the Reference PICC…) the ICS shall clearly

identify this limitation. The tests can be exceptionally performed on a modified hardware (i.e. different casing respecting 15 cm min around antenna). However, the PCD software version, reference of the contactless reader or antenna module, software version of the contactless reader or antenna module shall be tested as declared in the product description of the ICS. It shall be then clearly indicated in the certification letter what has been tested.

Test results shall be considered as FAIL if the PICC or PCD has an erratic behaviour*.

* No action external to the test procedure is allowed to help the PICC or PCD pass the test (for example a reset).

4.3 Producing the Test Report

The test report is provided by the Test Laboratory and shall be made up of:

- A header section including:
    - Identification of the Test Laboratory
    - Version number
    - Signature
    - Reference of the ICS
    - ICS data sheet
    - Reference of the form request
    - Reference of used test tool
    - Start and end dates of test execution
- Test results based on the following test result templates:
    - for PCD product, templates provided in Annex C of the present document for Analog test results and in Annex E for Protocol and Digital test results.
    - for PICC product, templates provided in Annex D of the present document for Analog test results and in Annex F for Protocol and Digital test results,
- Any measurement files, logs, curves that may be requested or helpful to understand the test results.

The test results shall indicate the status of each compulsory test in the appropriate column:

- N/A: when the test is not applicable due to the product characteristics indicated in the ICS,
- PASS: only when all steps of the test procedure succeeded,
- FAIL: when at least one of the steps of the test procedure failed,
- INCONCLUSIVE: when the lab was not able to conclude on the test result or to execute the test.

For each FAIL test, the Test Laboratory shall precisely describe the observed behaviour versus the expected behaviour.

For each INCONCLUSIVE or N/A test, the Test Laboratory shall explain why the test is INCONCLUSIVE or N/A.

When the measurement is out of the limit, but within the tolerance margin – as defined in section 5.6 of the ISO/IEC TS 24192-2:2021 test plan [REF2], or in Annex D of the STA Test Tools Validation Methodology [REF3], – the test result shall be stated as INCONCLUSIVE.

For informative tests, the status shall be INCONCLUSIVE and the test results shall be logged in a separate section of the test report.

When tests are performed on 3 samples, the test results shall follow the following rules:

- the test result shall be FAIL, if the test result is FAIL for any one of the 3 samples,
- the test result shall be PASS, if the test result is PASS for all 3 samples,
- measurements, when required by the test method, shall be provided on CB demand for each sample.

For product acting both as a PICC and a PCD, the test results shall be provided for each mode.

For a multi component product, a test report shall be provided for each test campaign performed with a Reference UICC.

For a battery powered PICC, the test results shall be provided for both nominal and “battery low” modes.

5 Process for Product Re-Certification

The following sections apply in case of product change and/or certification upgrade.

Section 5.1 applies when the initial and new certifications are performed in accordance with the same version of the STA certification process.

Section 5.2 applies when the initial and new certifications are performed on the same product samples.

When product change and certification upgrade occur, the applicable tests from both sections shall be performed.

5.1 Re-Certification Following a Product Change

Changes applied to an already certified product will require part or full execution of the test campaign to grant a certification for the changed product.

Depending on the change impacts, a subset of the tests shall be executed.

a) Mono Component Product:

Type of change	Required tests
PICC – Change impacting RF performance (card body structure, antenna, chip, settings…)	PICC Analog test plan in Annex D
PICC – Change impacting Digital behaviour (protocol change, chip…)	PICC Digital and Protocol test plan in Annex F
PICC - Application change	None
PICC - Production site change	PICC Analog test plan in Annex D
PCD – Change impacting RF performance (casing, antenna, antenna tuning, settings…)	PCD Analog test plan in Annex C
PCD – Change impacting Digital behaviour (polling sequence, protocol change…)	PCD Digital and Protocol test plan in Annex E
PCD - Application change	None
PCD - Production site change	PCD Analog test plan in Annex C

b) Multi Component Product: UICC-Based NFC Handheld Terminals

Type of change	Required tests
Antenna change	PCD Analog test plan in Annex C PICC Analog test plan in Annex D
Application change	None
Operating System change	None if no impact on NFC interface
NFC Controller firmware change	PCD Analog test plan in Annex C PICC Analog test plan in Annex D PCD Digital and Protocol test plan in Annex E PICC Digital and Protocol test plan in Annex F
CLF Driver Software change	PCD Digital and Protocol test plan in Annex E PICC Digital and Protocol test plan in Annex F
Production site change	PCD Analog test plan in Annex C PICC Analog test plan in Annex D

c) Multi Component Product: UICC-Based USB NFC Tokens

Type of change	Required tests
Antenna change	PCD Analog test plan in Annex C PICC Analog test plan in Annex D
Application change	None
Operating System change	None if no impact on NFC interface
NFC Controller firmware change	PCD Analog test plan Annex C PICC Analog test plan in Annex D PCD Digital and Protocol test plan in Annex E PICC Digital and Protocol test plan in Annex F
Production site change	PCD Analog test plan in Annex C PICC Analog test plan in Annex D

For any other change not listed in the table above, a complete test campaign shall be executed for granting certification for the changed product.

5.2 Certification Upgrade

To upgrade a product certification based on CEN/TS 16794:2015 or CEN/TS 16794:2017 to a certification based on ISO/IEC TS 24192:2021 with no product change, all the Digital tests shall be performed in Annex E (for a PCD product) and Annex F (for a PICC product). The tests in Annex C and Annex D shall be carried out depending on the initial certification in accordance with the table below. The symbol “X” means that the complete test shall be performed.

Product Type	Test	Details	Tests to perform with an initial certification based on CEN/TS 16794:2015	Tests to perform with an initial certification based on CEN/TS 16794:2017
PCD	6.1.1	Alternating magnetic field ([REF7], Table O.8)	X	Perform this test only with Reference PICC 3
PCD	N/A	Carrier frequency *fc* as defined in ISO/IEC 14443-2:2020, 6.1 ([REF7], Table O.9)	X	X
PCD	7.1.1	PCD field strength ([REF7], Table O.9)	Perform this test only at the new positions of Range A + All positions with Class 1 (V_{load} = 4,5V)	Perform this test only at the new positions of Range A + All positions with Class 1 (V_{load} = 4,5V)
PCD	7.1.4	Modulation index and waveform (Table O.9)	Perform this test only with Reference PICC 1 (V_{load} = 4,5V)	Perform this test only with Reference PICC 1 (V_{load} = 4,5V)
PCD	7.1.5	Phase stability	X	X
PCD	7.1.6	Load modulation reception for PICC to PCD bit rates of *fc*/128, *fc*/64, *fc*/32 and *fc*/16 ([REF7], Table O.9)	X	X
PCD	7.1.7	Load modulation reception for all supported PICC to PCD bit rates (Annex G.5)	X	X
PCD	7.1.8	PCD EMD immunity test (Table O.9)	X (All supported PICC to PCD bit rates)	X (All supported PICC to PCD bit rates)
PICC	N/A	Antenna size and PICC class verification as defined in ISO/IEC 14443-1:2018, Annex A ([REF7], Table O.13)	X	X
PICC	6.2.1	Alternating magnetic field ([REF7], Table O.13)	X	
PICC	7.2.1	PICC transmission ([REF7], Table O.14)	X	X
PICC	7.2.2	PICC EMD level and low EMD time test ([REF7], Table O.14)	X	X
PICC	7.2.3	PICC reception ([REF7], Table O.14)	X	X
PICC	7.2.5	PICC maximum loading effect ([REF7], Table O.14)	X	

Annex A UICC Profiles for Multi Component PICC Test

This annex lists the UICC profiles to be used for performing tests on multi-component PICC UICC-based products. Five UICC profiles have been defined: 2 for Type A, 2 for Type B and 1 for Type A and Type B. Each product shall be tested with the UICCs corresponding to the protocol(s) supported and described in its ICS [PICC3.1] box.

For optimisation, it is not necessary to perform a full set of tests for each profile, as described in the following paragraphs.

A.1 UICC Profiles Type A

There are 2 profiles to be tested, as described in the following table. Protocol tests shall be performed on both profiles and RF tests on Profile 2 only.

Type A	ICS section	Profile 1	Profile 2
UID	[PICC4.4]	Random	Fixed - double size
SAK	N/A	FBh	20h
ATQA	N/A	100Ch	4400h
FWI	[PICC4.5]	0	7
SFGI	[PICC4.6]	0	8
CID	[PICC4.8]	No	Yes
Maximum bit rate in both directions	[PICC4.1] [PICC4.2]	*fc*/128 (~106 kbit/s)	*fc*/16 (~848 kbit/s)

NOTE Profile 1 is EMV compatible.

A.2 UICC Profiles Type B

There are 2 profiles to be tested. Protocol tests shall be performed on both profiles and RF tests on Profile 4 only.

Type B	ICS section	Profile 3	Profile 4
PUPI	[PICC5.4]	Random	Fixed
AFI	[PICC5.11]	00h	00h
FWI	[PICC5.5]	0	7
SFGI	[PICC5.9]	0	8
CID	[PICC5.7]	No	Yes
Maximum bit rate in both directions	[PICC5.1] [PICC5.2]	*fc*/128 (~106 kbit/s)	*fc*/16 (~848 kbit/s)

NOTE Profile 3 is EMV compatible.

A.3 UICC Profile Type A and Type B

There is only one profile to be tested. Protocol tests shall be performed on this profile, but no RF tests.

Type A and Type B	ICS section	Profile 5
UID	[PICC4.4]	Random
SAK	N/A	20h
ATQA	N/A	0400h
FWI	[PICC4.5]	7
SFGI	[PICC4.6]	8
CID	[PICC4.8]	Yes
Maximum bit rate in both directions	[PICC4.1] [PICC4.2]	*fc*/16 (~848 kbit/s)
PUPI	[PICC5.4]	Random
AFI	[PICC5.11]	00h
FWI	[PICC5.5]	7
SFGI	[PICC5.9]	8
CID	[PICC5.7]	Yes
Maximum bit rate in both directions	[PICC5.1] [PICC5.2]	*fc*/16 (~848 kbit/s)

NOTE Profile 5 is not EMV compatible.

Annex B List of Tests Applicable for PICC in “Battery Low Mode”

B.1 PICC Analog Test (detailed)

All the tests described in Annex D performed at ambient temperature are applicable.

B.2 PICC Digital and Protocol Test (detailed)

All the tests described in Annex F are applicable.

Annex C List of Analog Tests Applicable for PCD Product

Test reference	Test title	Test conditions						Test result	Comments
		PCD to PICC bit rate	PICC to PCD bit rate	Reference PICC resonance frequency	Temperature	Reference PICC	Measurement positions		
From [REF7]									
6.1.1	Alternating magnetic field (Table O.8)	N/A	N/A	19 MHz	Ambient	1	See [REF2], 6.1.1		
						3	See [REF2], 6.1.1		
N/A	Carrier frequency *fc* as defined in ISO/IEC 14443-2:2020, 6.1 (Table O.9)	N/A	N/A	N/A	Ambient	N/A	N/A		
7.1.1	PCD field strength (Table O.9)	N/A	N/A	19 MHz for maximum PCD field strength 13,56 MHz for minimum PCD field strength	Ambient	1	Range A		
						2	Range A		
						3	Range A		
							Range B		
7.1.4	Modulation index and waveform (Table O.9)	All supported PCD to PICC bit rates	N/A	16,5 MHz	Ambient	1	Position A1		
						2	Position A1		
						3	Position B1 or Position A1		
						Cal. Coil	Arbitrary position		
7.1.5	Phase stability	N/A	N/A	13,56 MHz	Ambient	1	Position A1		

Test reference	Test title	Test conditions						Test result	Comments
		PCD to PICC bit rate	PICC to PCD bit rate	Reference PICC resonance frequency	Temperature	Reference PICC	Measurement positions		
7.1.6	Load modulation reception for PICC to PCD bit rates of *fc*/128, *fc*/64, *fc*/32 and *fc*/16 (Table O.9)	One supported PCD to PICC bit rate	All supported PICC to PCD bit rates	N/A	Ambient	1	Range A		
						2	Range A		
						3	Range A		
							Range B		

Test reference	Test title	Test conditions						Test result	Comments
		PCD to PICC bit rate	PICC to PCD bit rate	Reference PICC resonance frequency	Temperature	Reference PICC	Measurement positions		
7.1.7	Load modulation reception for all supported PICC to PCD bit rates (Annex G.5)	One supported PCD to PICC bit rate	All supported PICC to PCD bit rates	13,56 MHz	Ambient	1	Range A		
						2	Range A		
						3	Range A		
							Range B		
					Minimum	1	Position A2		
						3	Position B2 or Position A2		
					Maximum	1	Position A2		
						3	Position B2 or Position A2		
				15 MHz	Ambient	1	Range A		
						2	Range A		
						3	Range A		
							Range B		
					Minimum	1	Position A2		
						3	Position B2 or Position A2		
					Maximum	1	Position A2		
						3	Position B2 or Position A2		
7.1.8	PCD EMD immunity test (Table O.9)	One supported PCD to PICC bit rate	All supported PICC to PCD bit rates	13,56 MHz	Ambient	1	Position A1		
							Position A2		

Annex D List of Analog Tests Applicable for a PICC Product

Test reference	Test title	Test conditions					Test result	Comments
		PCD to PICC bit rate	PICC to PCD bit rate	Temperature	Field strength	Waveform conditions		
From [REF7]								
N/A	Antenna size and PICC class verification as defined in ISO/IEC 14443-1:2018, Annex A (Table O.13)	N/A	N/A	Ambient	N/A	N/A		
6.2.1	Alternating magnetic field (Table O.13)	N/A	N/A	Ambient	$H = \frac{4}{3} H_{max}$	N/A		
7.2.1	PICC transmission (Table O.14)	One supported PCD to PICC bit rate	All supported PICC→PCD bit rates, except bit rates of *fc*/64 (~212 kbit/s), *fc*/32 (~424 kbit/s) and *fc*/16 (~848 kbit/s)	Ambient	$H = H_{min}$	see [REF7]		
					H = 2,0 A/m	see [REF7]		
					H = 2,5 A/m	see [REF7]		
					H = 3,5 A/m	see [REF7]		
					H = 4,5 A/m	see [REF7]		
					H = 6,0 A/m	see [REF7]		
					$H = H_{max}$	see [REF7]		
				Minimum	$H = H_{min}$	see [REF7]		
					$H = H_{max}$	see [REF7]		
				Maximum	$H = H_{min}$	see [REF7]		
					$H = H_{max}$	see [REF7]		

Test reference	Test title	Test conditions					Test result	Comments
		PCD to PICC bit rate	PICC to PCD bit rate	Temperature	Field strength	Waveform conditions		
7.2.2	PICC EMD level and low EMD time test (Table O.14)	*fc*/128 (~106 kbit/s)	*fc*/128 (~106 kbit/s)	Ambient	$H = H_{min}$	see [REF7]		
					H = 2,0 A/m	see [REF7]		
					H = 2,5 A/m	see [REF7]		
					H = 3,5 A/m	see [REF7]		
					H = 4,5 A/m	see [REF7]		
					H = 6,0 A/m	see [REF7]		
					$H = H_{max}$	see [REF7]		
7.2.3	PICC reception (Table O.14)	All supported PCD to PICC bit rates	One supported PICC to PCD bit rate	Ambient	$H = H_{min}$	see [REF7]		
					H = 2,0 A/m	see [REF7]		
					H = 2,5 A/m	see [REF7]		
					H = 3,5 A/m	see [REF7]		
					H = 4,5 A/m	see [REF7]		
					H = 6,0 A/m	see [REF7]		
					$H = H_{max}$	see [REF7]		
7.2.5	PICC maximum loading effect (Table O.14)	N/A	N/A	Ambient	see [REF7], 7.2.5.2	N/A		

Test reference	Test title	Test conditions					Test result	Comments
		PCD to PICC bit rate	PICC to PCD bit rate	Temperature	Field strength	Waveform conditions		
7.2.6	PICC operating field strength (Table O.14)	All supported PCD to PICC bit rates	One supported PICC to PCD bit rate	Ambient	$H = H_{min}$	see [REF7]		
					H = 2,0 A/m	see [REF7]		
					H = 2,5 A/m	see [REF7]		
					H = 3,5 A/m	see [REF7]		
					H = 4,5 A/m	see [REF7]		
					H = 6,0 A/m	see [REF7]		
					$H = H_{max}$	see [REF7]		
				Minimum	$H = H_{min}$	see [REF7]		
					$H = H_{max}$	see [REF7]		
				Maximum	$H = H_{min}$	see [REF7]		
					$H = H_{max}$	see [REF7]		

Annex E List of Digital Tests Applicable for a PCD Product

Test reference	Test title	Test result	Comments
From [REF7]			
H.1.7	Measuring timing (Table O.11)		
8.1.1	PCD EMD recovery test (Table O.11)		
H.2.1	Frame Delay Time PICC to PCD (Table O.11)		
H.2.2	Request Guard Time (Table O.11)		
H.2.3	Handling of bit collision during ATQA (Table O.11)		
H.2.4	Handling of anticollision loop (Table O.11)		
H.2.5	Handling of RATS and ATS (Table O.11)		
H.2.7	Frame size selection mechanism (Table O.11)		
H.2.8	Handling of Start-up Frame Guard Time (Table O.11)		
H.2.9	Handling of the CID during activation by the PCD (Table O.11)		
H.2.10	Handling of parity bit (Table O.11)		
H.3.2	Frame size selection mechanism (Table O.11)		
H.3.3	Handling of the CID during activation by the PCD (Table O.11)		
H.3.4	Frame Delay Time PICC to PCD (TR2) (Table O.11)		
H.3.5	Handling of Start-up Frame Guard Time (Table O.11)		
H.3.6	Type B PCD framing tests (Table O.11)		
H.4.2	Handling of the polling loop (Table O.11)		
H.4.3	Reaction of the PCD to request for waiting time extension (Table O.12)		

Test reference	Test title	Test result	Comments
H.4.4	Error detection and recovery (Table O.12)		
H.4.5	Handling of NAD during chaining (Table O.12)		
H.5	Continuous monitoring of packets sent by the PCD (Table O.11 and Table O.12)		
Annex I	High bit rate selection (Table O.12)		
L.1.1	Frame format selection (Table O.12)		
L.2.1	Error correction mechanism (Table O.12)		
From [REF2]			
6.1.2	RFU bits and values reception test		
6.2.1	AFI value sent by the PCD		
6.2.2	PCD Type A time-to-detection		
6.2.3	PCD Type B time-to-detection		
6.2.4	Correct detection of a Type A PICC after having previously received modulated field		
6.2.5	Correct detection of a Type B PICC after having previously received modulated field		
6.2.6	Non-ISO/IEC 14443-4 protocol management by the PCD		

Annex F List of Digital Tests Applicable for a PICC Product

Test reference	Test title	Test result	Comments
From [REF7]			
G.1.5	RFU values (Table O.17)		
G.1.7	Measuring timing (Table O.16)		
G.3.2	Polling (Table O.16)		
G.3.3	Testing of the PICC Type A state transitions (Table O.16)		
G.3.4	Handling of Type A anticollision (Table O.16)		
G.3.6	Handling of PPS request (Table O.17)		
G.3.7	Handling of FSD (Table O.17)		
G.3.8	Handling of Frame Delay Time PICC to PCD and SFGT (Table O.16)		
G.3.9	PICC bit rates capability (Table O.17)		
G.4.2	Polling (Table O.16)		
G.4.3	PICC framing and bit rates capability (Table O.16)		
G.4.4	Testing of the PICC Type B state transitions (Table O.16)		
G.4.5	Handling of Type B anticollision (Table O.16)		
G.4.6	Handling of ATTRIB (Table O.16)		
G.4.7	Handling of Maximum Frame Size (Table O.16)		
G.4.8	Handling of TR2 and SFGT (Table O.16)		
G.5.2	PICC reaction to ISO/IEC 14443-4 scenarios (Table O.17)		
G.5.3	Handling of PICC error detection (Table O.17)		
G.5.4	PICC reaction on CID (Table O.17)		
G.5.5	PICC reaction on NAD (Table O.17)		

Test reference	Test title	Test result	Comments
G.5.6	PICC reaction on S(PARAMETERS) blocks (Table O.17)		
G.5.7	PICC supporting Type A and Type B (Table O.16)		
L.1.2	Frame format selection (Table O.17)		
L.2.2	Error correction mechanism (Table O.17)		
L.3.1	PICC reaction to ISO/IEC 14443-4 scenarios when frame with error correction is activated (Table O.17)		
L.3.2	Reduction of bit rate during chaining when frame with error correction is activated (Table O.17)		
From [REF2]			
7.1.2	RFU bits and values reception test		
7.2.1	Field ramp-ups and shut-offs		

Annex G Corrigendum to the ISO/IEC TS 24192-2:2021 Test Plan

G.1 PICC Test Cases ISO/IEC 10373-6:2020,

G.1.1 Clause G.4.8.2

In Table G.61, the following step shall be added (after step 1):

- Nothing in the TR2 to apply column,
- "WUPB(1)[a]" in the PICC-test-apparatus column,
- "ATQB or Extended ATQB" in the PICC column.

Step	TR2 to apply	PICC-test-apparatus		PICC
New step after step 1	–	WUPB(1)[a]	⟶	
			⟵	ATQB or Extended ATQB

G.1.2 Clause O.2

In Table O.14, in specific test conditions column, replace "Any PICC to PCD bit rate may be used" by "if possible, set PICC to PCD bit rate at selected PCD to PICC bit rate".

G.2 RFU Bits with an Unexpected Value (bit at 1) in the PPS0

ISO/IEC TS 24192-2, 7.1.2.2.1.3 test procedure 3 (PPS0) shall consider ISO/IEC 14443-4:2018 corrigendum 2. The PICC may therefore:

- either ignore the RFU bits and continue its processing normally,
- or apply ISO/IEC 14443:2018, 5.7.2.2 b.), i.e. disable the PPS request (stop responding to received PPS requests) and remain in receive mode.

G.3 PCD Test Cases ISO/IEC 10373-6:2020, H.2.7.3 and H.3.2.3

UT_TEST_COMMAND2 size shall not exceed the PCD internal output buffer size.
Answer to UT_TEST_COMMAND2 size shall not exceed the PCD internal input buffer size.

G.3.1 Test Case H.2.7.3

This test shall be executed only for FSC values strictly less than the PCD internal buffer size and at least for FSCI set to '0' and to the coding of the largest FSC value that is strictly less than the PCD internal buffer size.

G.3.2 Test Case H.3.2.3

This test shall be executed only for Maximum Frame Size values strictly less than the PCD internal buffer size and at least for Maximum Frame Size Code in ATQB set to '0' and to the coding of the Maximum Frame Size value that is strictly less than the PCD internal buffer size.

G.4 PCD Test Case ISO/IEC 10373-6:2020, H.4.4.3.9

Apply scenario H.25 with at least the combinations 1 and 9 of Table H.38.

G.5 PCD Test Case ISO/IEC 10373-6:2020, 7.1.6 and 7.1.7

Replace the test procedure 1 and test procedure 2 of 7.1.6 defined in ISO/IEC 10373-6:2020 by following tests procedures:

"7.1.6.5 Test procedure 1

The PCD shall operate under the conditions defined in ISO/IEC 10373-6:2020, 7.1.6.4 after the selection of that PICC to PCD bit rate. The PCD shall correctly react to a received PICC response at the selected PICC to PCD bit rate.

a) Place the Active Reference PICC in an applicable test position on the DUT. Note the Active Reference PICC CON3 DC voltage corresponding to the field condition.

b) Place the Active Reference PICC in the DUT position of the Test PCD assembly.

c) Calibrate the Test PCD assembly to produce field condition noted in step a).

d) Adjust the Active Reference PICC input signal at CON1 to produce $f_c - f_s$ and $f_c + f_s$ sidebands amplitudes of $V_{LMA,\,min,\,PCD}$ associated with the noted field strength and PICC class as specified in ISO/IEC 14443-2.

NOTE The V_{LMA} is measured as described in ISO.IEC 10373-6:2020 7.2.1.

e) Select an applicable phase drift condition defined in ISO/IEC 10373-6:2020, 7.1.6.4.

f) Produce a response at a PICC to PCD bit rate of $f_c/128$ and record the initial phase $\emptyset_{LM,\,INIT}$ using the PICC amplitude and phase drift analysis tool of Annex N.

g) Place the Active Reference PICC in the test position of step a).

h) The PCD shall correctly detect the Active Reference PICC response.

i) Repeat step h) at least for all mandatory $\emptyset_{LM,\,INIT}$ values defined in ISO/IEC 10373-6:2020, 7.1.6.4.

j) Repeat steps h) and i) for all applicable phase drift conditions defined in ISO/IEC 10373-6:2020, 7.1.6.4.

k) Repeat step b) and steps d) to j) for the highest PICC to PCD bit rate corresponding to every supported subcarrier f_s.

l) Repeat step b) and steps d) to k) at least for all mandatory PCD V_{LMA} values defined in ISO/IEC 10373-6:2020, 7.1.6.4.

m) Repeat steps a) to l) at least for all applicable test positions.

7.1.6.6 Test procedure 2

a) Place the Active Reference PICC in an applicable test position on the DUT. Note the Active Reference PICC CON3 DC voltage corresponding to the field condition.

b) Place the Active Reference PICC in the DUT position of the Test PCD assembly.

c) Calibrate the Test PCD assembly to produce field condition noted in step a).

d) Adjust the Active Reference PICC input signal at CON1 to produce $f_c - f_s$ and $f_c + f_s$ sidebands amplitudes of $V_{LMA, min, PCD}$ associated with the noted field strength and PICC class as specified in ISO/IEC 14443-2.

NOTE The V_{LMA} is measured as described in ISO.IEC 10373-6:2020 7.2.1.

e) Select phase drift condition A1 or B1 defined in ISO/IEC 10373-6:2020, 7.1.6.4, depending on the PICC communication signal interface and the PICC to PCD bit rate.

f) Produce a response and record the initial phase $Ø_{LM, INIT}$ using the PICC amplitude and phase drift analysis tool of ISO/IEC 10373-6:2020, Annex N.

g) Place the Active Reference PICC in the position of step a).

h) The PCD shall correctly detect the Active Reference PICC response.

i) Repeat step h) at least for all mandatory $Ø_{LM, INIT}$ values defined in ISO/IEC 10373-6:2020, 7.1.6.4.

j) With $f_c + f_s$ sideband amplitude of PCD V_{LMA} as adjusted in step d), repeat steps h) and i) for $f_c - f_s$ sideband amplitude increased by 2,0 dB, 4,0 dB, 6,0 dB, 8,0 dB and 10,0 dB.

k) With $f_c - f_s$ sideband amplitude of PCD V_{LMA} as adjusted in step d), repeat steps h) and i) for $f_c + f_s$ sideband amplitude increased by 2,0 dB, 4,0 dB, 6,0 dB, 8,0 dB and 10,0 dB.

l) Repeat steps b), d) and f) to k) for the highest supported PICC to PCD bit rate corresponding to every subcarrier f_s.

m) Repeat steps a) to l) at least for all applicable test positions.

7.1.6.7 Test report

The test report shall confirm the intended operation at the mandatory PICC to PCD bit rate of $f_c/128$ for Test procedure 1 and Test procedure 2. For PCDs supporting one or more of the optional PICC to PCD bit rates the test report shall confirm the intended operation at the supported PICC to PCD bit rates tested for Test procedure 1 and Test procedure 2."

Modify ISO/IEC 10373-6 clause 7.1.7.1 Purpose as described below to apply 7.1.7. at all supported PICC to PCD bit rates instead of PICC to PCD bit rates of *fc*/8, *fc*/4 and *fc*/2 only. This test method uses the loading effect of the passive Reference PICC in replacement of load of active Reference PICC. Replace the clause 7.1.7 with the following:

"7.1.7 Load modulation reception for all PICC to PCD bit rates

7.1.7.1 Purpose

This test is used to verify that a PCD correctly detects the load modulation of a PICC which conforms to ISO/IEC 14443-2 for all supported PICC to PCD bit rates.

7.1.7.2 Procedure

a) Tune the Reference PICC to 13,56 MHz as described in 5.5.2.4 and switch the jumper J1 to position 'c' and the jumper J2 to position 'b'.

b) Place the Reference PICC in an applicable test position on the DUT.

c) Apply and adjust a DC voltage at CON2 to obtain a DC voltage at connector CON3 of V_{load} as defined in Table 3.

d) Increase the modulation signal amplitude at CON1 to produce responses until the PCD detects at least 10 of them consecutively.

e) Place the Reference PICC in the DUT position on the Test PCD assembly.

f) Adjust the Test PCD assembly to produce a field strength H which gives the same voltage at CON3 and note the corresponding field strength by reading the calibration coil voltage.

g) Measure the Reference PICC load modulation amplitude V_{LMA} as described in 7.2.1 and compare it with $V_{LMA,\,min,\,PCD}$ associated with the noted field strength. This measured V_{LMA} defines the PCD sensitivity criterion in order to compare with $V_{LMA,\,min,\,PCD}$ to perform these test measurements.

h) Repeat steps b) to g) at least for all applicable test positions for PICC to PCD bit rates of $f_c/128$, $f_c/8$, $f_c/4$ and $f_c/2$, if supported.

i) Repeat steps a) to h) with Reference PICC tuned to resonance frequency 15 MHz.

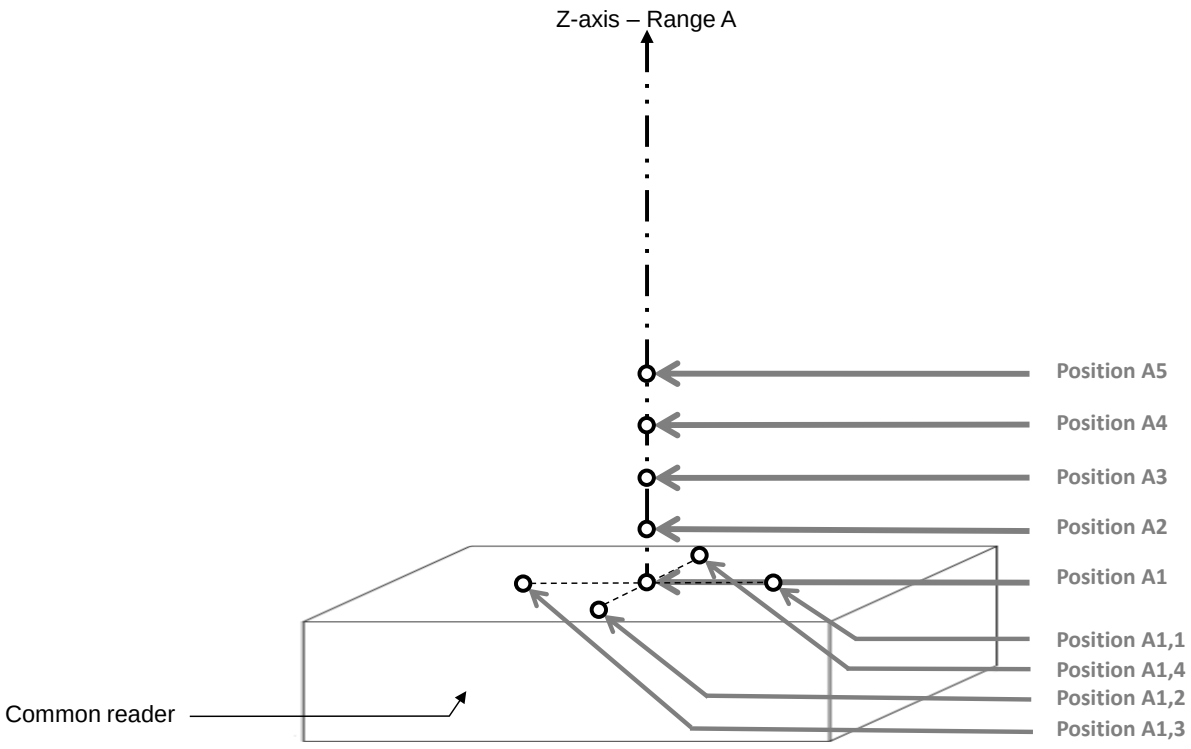
Any position in which the PCD sensitivity is above $V_{LMA,\,min,\,PCD}$ shall be considered FAIL.

7.1.7.3 Test report

The test report shall give the PCD load modulation sensitivity for the tested positions."

G.6 PCD Operating Volume for Common Readers

Replace the ISO/IEC TS 24192-1 Figure 3 (Range A test positions for Common reader) in 8.1.3 by the following:



Replace the ISO/IEC TS 24192-1 [Rdr3] For Common readers in 8.2 by the following:

"— All the [Rdr1] requirements tested with the Reference PICC 1, Reference PICC 2 and Reference PICC 3 shall be complied with for the following range A test positions: Position A1, Position A1,1, Position A1,2, Position A1,3, Position A1,4, Position A2, Position A3, Position A4 and Position A5 (see Figure 3).

— There are no requirements applicable to range B."

G.7 PCD LMA Procedures Execution Time

Replace the ISO/IEC TS 24192-2 clause 6.1.1 about load modulation reception tests by the following:

"— Load modulation reception tests (ISO/IEC 10373-6:2020, Table O.9, i.e 7.1.6 and 7.1.6) shall be performed at least:

— at ambient temperature with:

— Reference PICC 1, 2 and 3 in Position A1' at 0° and 90°, Position A3, Position A5 and Position A7 at 0° and 90° for IFM readers and Position A1' at 0°, Position A3 and Position A5 for Common readers.

Position A1' is the position where the field is maximum between Position A1, Position A1,1 Position A1,2, Position A1,3 and Position A1,4.

— Reference PICC 3 in all range B test positions for IFM readers.

— at minimum and maximum temperatures with:

— Reference PICC 1 in Position A2,

— Reference PICC 3 in Position B2 for IFM readers and Position A2 for Common readers."

Performing load modulation reception tests at minimum and maximum temperatures is optional until January 1st, 2025.

G.8 Climatic Chamber Conditions

G.8.1 General Conditions

For PCD and PICC testing, the DUT shall be located in an area without additional material disturbing the magnetic field. To confirm that there is no influence, one of following verifications shall be performed:

- The DUT and the test environment shall be more than 15 cm from any conductive material.
- For PCD testing:
  - First, 7.1.6 and 7.1.7 test shall be performed at ambient temperature with the PCD under test placed outside the climatic chamber.
  - Then, the tests shall be performed with the PCD under test placed inside the climatic chamber at the same temperature and at least 90% of LMA measurements shall deviate by less than +2 mV or −2 mV from the results obtained outside the climatic chamber.
- For PICC testing:
  - First, 7.2.1 test shall be performed at ambient temperature with the PICC under test placed outside the climatic chamber.

- Then, the test shall be performed with the PICC under test placed inside the climatic chamber at the same temperature and LMA measurements shall not deviate from more than +5 % or −5 % from the results obtained outside the climatic chamber.

G.8.2 PCD Analog Tests

The PCD Analog tests shall be performed at minimum and maximum temperatures with the following test conditions:

- The PCD under test shall be placed inside the climatic chamber.
- The Test PCD assembly shall be placed outside the climatic chamber.
- The Reference PICC shall be alternately placed in the DUT position of the PCD under test into the climatic chamber and placed in the DUT position of the Test PCD assembly outside the climatic chamber.

G.9 Table O.9 – Test of ISO/IEC 14443-2 PCD Parameters

Add following row after the row "Modulation index m and waveform":

Phase stability	7.1.5				Test is performed after step INITIALIZE_PCD_TEST_MODE (No polling commands).

- **END OF DOCUMENT** -