ISO/IEC JTC1/SC17 2008-12-05
Cards and personal identification

ISO/IEC JTC1/SC17 N 3621 **WG8 N 1498**

DOCUMENT TYPE: Notification of Ballot

TITLE: Notification of Ballot: ISO/IEC 10373-6:2001/FPDAM 7 – Identification Cards – Test methods – Part 6: Proximity cards – Amendment 7: Test methods for ePassport

BACKWARD POINTER:

SOURCE: SECRETARIAT ISO/IEC JTC1/SC17

STATUS: Disposition of comments for 17n3533 are contained in 17n3620.

This ballot has been posted to the ISO Electronic balloting application and is available under the Balloting Portal, Committee Internal Balloting.

ACTION ID: FYI

WORK ITEM: 52033

DUE DATE: 2009-04-06

DISTRIBUTION: P and L-Members of ISO/IEC JTC1/SC17
JTC1 Secretariat
ISO/IEC ITTF

MEDIUM: SERVER

NO. OF PAGES: 88

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ISO/IEC JTC 1/SC 17 WG8 N 1471 R1

Date: 2008-11-27

ISO/IEC 10373-6:2001/FPDAM 7

ISO/IEC JTC 1/SC 17/WG 8

Secretariat: DIN

Identification cards — Test methods — Part 6: Proximity cards

Amendment 7: Test methods for ePassport

Cartes d'identification — Méthodes d'essai — Partie 6: Cartes de proximité

Amendment 7: Méthodes d'essai pour ePassport

Warning

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Document type: International Standard
Document subtype: Amendment
Document stage: (40) Enquiry
Document language: E

C:\Doc\iso\WG3\Editing\Unified\Cleaned\Gratz\PostGraz\Latest\wg8n1471_Text_of_10373-6_FPDAM7vis.doc STD Version 2.1c2

Contents

Page

Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of the joint technical committee is to prepare International Standards. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

Amendment 7 to ISO/IEC 10373-6:2001 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 17, Cards and personal identification.

Identification cards — Test methods — Part 6: Proximity cards

AMENDMENT 7: Test methods for ePassport

Page 2, section 3.1

Add the following definitions and reorder alphabetically:

"

3.1.12
Sample
A sample is one piece of the total number of PICCs required and presented for testing according to this specification.

3.1.13
Room temperature
Room temperature (RT) is defined as any convenient temperature within the range of 23 °C ± 3 °C (73 °F ± 5 °F).

3.1.14
Threshold field strength
The threshold field strength is the minimum field strength to operate the PICC as intended (operational mode).

"

Page 3 section 3.2

Add the following Abbreviations and symbols in alphabetic order:

"

BAC	Basic Access Control
EAC	Extended Access Control
LDS	Logical Data Structure

"

Add the following annexes as Annex L, M and N to the standard:

"

Annex L
(informative)

ePassport PICC test methods

L.1 Scope

This annex defines a test plan for the PICC contactless part of the ePassport oriented PICC. These tests are divided into tests of the physical and electrical parameters according to ISO/IEC 14443-1:2000 and ISO/IEC 14443-2:2001, and tests of the initialization & anticollision and the transport protocol according to ISO/IEC 14443-3:2001 and ISO/IEC 14443-4:2001.

In order for the PICCs to operate correctly, many functional layers of technology should work together. The purpose of this annex is to define in depth the tests to be performed to minimize the probability that an error or fault remain undetected before the design is approved.

For ePassport compliance testing, this annex is normative.

L.2 General test requirements

The following sub-clauses specify the different test setups, the nominal values used for the tests, and a recommendation for the format of the test report.

Tests for bit rates of *fc*/128 and *fc*/32 are mandatory and should be applied. Other bit rates, when indicated in the ATS/ATQB should also be tested.

Depending on the implementation statement of the applicant, Type A or Type B tests should be performed.

All tests are mandatory unless specified as ″optional″ or ″conditional″. Conditional tests should be performed if they are applicable.

For tests of layers 1 and 2, the minimum number of samples provided for testing is three. The applicant may request that a larger number of samples be tested.

L.2.1 Test setup

The test PCD assembly (test apparatus) that is defined in this standard is the basis for the physical and electrical tests. When testing at higher bit rates, the matching network in ISO/IEC 10373-6:2001/AM5:2006 clause A.2.2, is used together with the PCD assembly.

For layer 2 tests (communication stability and operating field strength), the existing test PCD assembly has to be adapted to carry a PICC with the additional ability to center an ID-1 sized antenna of a PICC in the test PCD assembly.

The test PCD in the test setup is intended to be active in duration-limited measurements in order to avoid any overheating of the individual components (e.g. PICC). For all functional tests, the chip's self-heating effect may not exceed 25 °C over ambient temperature.

NOTE Some of the following tests are based on Class-1 sized antenna as defined herein (see L.3.1). If the antenna does not comply with the Class-1 specification, those tests might not generate accurate results.

L.2.2 Equipment

Most of the tests need some additional equipment, such as an arbitrary waveform generator and an RF amplifier. The oscilloscope probes should have an input capacitance C < 12 pF.

L.2.3 Nominal values

Unless otherwise specified, the following environmental parameters and nominal values should be used:

Table L.1 — Nominal values

Parameter	Value	To be applied to
Environment temperature	RT	Type A and B
Relative humidity	25 % to 75 %[a]	Type A and B
Bit rate	*fc*/128	Type A and B
Modulation	100%	Type A
Modulation index *m*	12 %	Type B
t_1	3 µs	Type A
t_2	0,5 µs	Type A
t_3	≤ 1,5 µs	Type A
t_4	400 ns	Type A
Overshoot	0%	Type A and B
Rise time t_r, fall time t_f	≤ 1 µs	Type B
Start Of Frame timing (SOF)	10,5 etu ″0″ followed by 2,5 etu ″1″	Type B
End Of Frame timing (EOF)	10,5 etu ″0″	Type B
Extra Guard Time (EGT)	1 etu	Type B
[a] Any convenient relative humidity within the specified range.		

Nominal values define the parameters in accordance with ISO/IEC 14443-2:2001.

L.2.4 Test report

The test report should include the number of successful evaluations versus the total number of evaluations for each sample and for each test. A description of each test, the information whether the result was a pass or a fail, and the date of the tests should be included.

For all functionality check tests, the report has to state what tools and methods have been used to verify the functionality of the PICC.

L.2.5 Implementation conformance statement

In order to set up the tests properly, an applicant should provide the information specified in Table L.2 — Test precondition table ″Information on the product″ below.

Table L.2 — Test precondition table ″Information on the product″

Information for test setup	Applicant declaration
Location of antenna in PICC • which page • which area in the page	
Size of antenna • dimensions • compliance to Class-1 definition of ISO/IEC 14443-1:2000	
Electrical parameters of antenna • resonance frequency range (if optional test is performed)	
Modulation type • Type A or B	
PICC shielded or not and how	
Bit rates supported as claimed by the ATS/ATQB • from PCD to PICC o 106 kbps o 212 kbps o 424 kbps o 848 kbps • from PICC to PCD o 106 kbps o 212 kbps o 424 kbps o 848 kbps	
Random or fixed UID (Type A) or random or fixed PUPI (Type B)	
Access control applied • Plaintext • Basic Access Control • Extended Access Control	
Authentication supported • Passive Authentication • Active Authentication	
Commands supporting WTX	

L.2.6 Test sequence

In order to minimize efforts, it is recommended to perform the tests with all samples in the same order as mentioned in this test specification. If the tests for each layer are carried out separately or are carried out with different samples, additional tests will be necessary. For destructive tests such as mechanical and electrical (layer 1) stress tests, it is often required to check if the PICC ″operates as intended″. ISO standards do not define these tests further, and thus this specification leaves them to the responsibility of the test laboratories. Section L.8 Functionality check test (informative) specifies optional tests to verify the PICC's functionality on the electrical and on the application level.

L.3 Layer 1 tests

L.3.1 Class-1 verification test (conditional)

L.3.1.1 Purpose

The purpose of this test is to check if the physical coil dimensions meet the requirements according to ISO/IEC 14443-1:2008. The PICC antenna should be entirely located within a zone defined by two rectangles:

— external rectangle: 81 mm x 49 mm

— internal rectangle: 64 mm x 34 mm, 3 mm radius

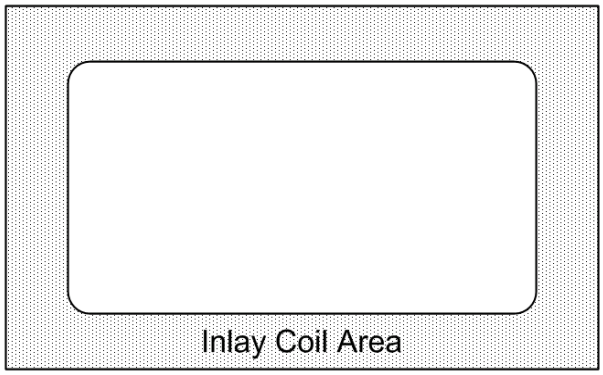

Figure L.1 — Class 1 Inlay Coil Area

NOTE This optional test should be applied if the applicant claims compliance with Class-1 in Table L.2 — Test precondition table ″Information on the product″.

A minimum of three samples should be used.

L.3.1.2 Test procedure

Place the PICC over Figure L.1 — Class 1 Inlay Coil Area and determine whether the PICC antenna coil is contained in the gray area.

L.3.1.3 Test report

The test report should state whether the coil geometry of the antenna is in accordance with Class-1 definition.

L.3.2 Static electricity (ESD) test

L.3.2.1 Purpose

The purpose of this test is to check the behavior of the PICC after an electrostatic discharge (ESD) on the test sample in accordance with this standard. The device under test is exposed to a simulated electrostatic discharge (ESD, human body model). Its basic operation is checked after the exposure.

The test should be performed according to the procedures defined in ISO/IEC 10373-6:2001/AM4:2006, clause 5.3, ″Static Electricity Test″.

L.3.2.2 Test procedure

Apply this test on a minimum of three samples.

NOTE In case the physical size of the PICC is different than ″Figure 2 — Test zones on PICC for ESD test" of ″5.3 Static electricity test″, the ″5.3 Static electricity test″ test procedure should be applied at the centers of a two-dimensional 1 cm by 1 cm mesh placed over the DUT.

L.3.2.3 Test report

In accordance with L.2.4, the test report, passed/tested, should combine L.8 Functionality check test (informative) results of all tested samples.

L.3.3 Alternating magnetic field test

L.3.3.1 Purpose

The purpose of this test is to check the behavior of the PICC in relation to alternating magnetic field exposure in accordance with this standard.

Alternating magnetic field test should be carried out at 13,56 MHz. No tests are required at other frequencies.

L.3.3.2 Test procedure

The test PCD assembly according to this standard should be used.

Perform the test according to the test procedure defined in clause 5.1.2 ″Alternating magnetic field; 12 A/m test″.

Apply ″5.1 Alternating magnetic field test″ on a minimum of three samples.

The test should be conducted with a field alternating between 0 A/m (rms), 10 A/m (rms) and 12 A/m (rms) as required in Clause 5.1.

L.3.3.3 Test report

In accordance with L.2.4, the test report, passed/tested, should combine ″L.8 Functionality check test (informative)″ results of all tested samples.

L.4 Layer 2 tests

Combinations of the following layer 2 and 3 tests are possible, provided that the test coverage is not affected; e.g. combining the frame delay time test with the operating field strength test or the operating field strength test with testing the load modulation amplitude is possible.

L.4.1 Load modulation amplitude test

L.4.1.1 Purpose

The purpose of this test is to determine conformance of the load modulation amplitude of the PICC to ISO/IEC 14443-2:2001 by performing the procedure set in clause 7.1 ″PICC load modulation amplitude″ of this standard.

L.4.1.2 Test procedure

For this test, it is recommended to have signal patterns that start with the RF off, and then produce an unmodulated field with nominal 13,56 MHz carrier at the field level required by the test for 5 ms prior to modulating this field with a REQA or a REQB command according to the used type. The nominal 13,56 MHz carrier should continue without modulation following the command for a recommended one second.

It is recommended to switch off the carrier for 5 ms before continuing at the next field level.

Perform the test according to Figure L.2 — Test procedure for the load modulation amplitude test below.

Perform ″7.1 PICC load modulation amplitude″ test on a minimum of 3 samples at all three temperatures.

At temperatures -10 °C and RT:

— mandatory: 1,5 A/m (rms), 4,5 A/m (rms), 7,5 A/m (rms)

— optional : 2,5 A/m (rms), 3,5 A/m (rms), 5,5 A/m (rms), 6,5 A/m (rms)

At temperature 50 °C:

— mandatory: 1,5 A/m (rms), 4,5 A/m (rms), 6,0 A/m (rms)

— optional : 2,5 A/m (rms), 3,5 A/m (rms), 5,5 A/m (rms)

In case any of the mandatory tests fail to meet ISO/IEC 14443-2:2001, the tests with the optional field strengths should be carried out.

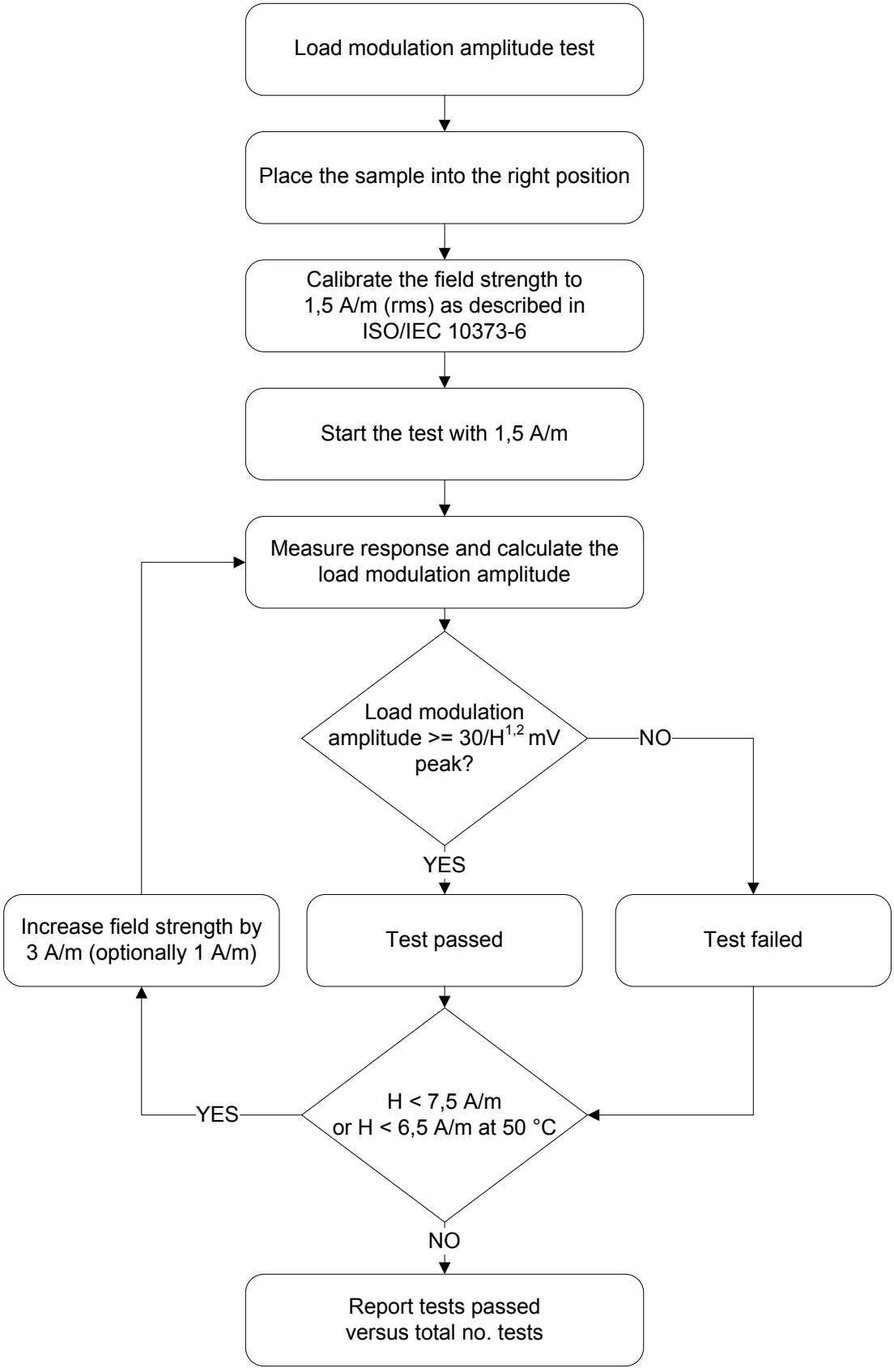

Figure L.2 — Test procedure for the load modulation amplitude test

NOTE 1 When executing the test at 50 °C replace the condition *"H* < 7,5 A/m (rms)*"* with *"H* < 6 A/m (rms)*"*, and the last step should be 6 A/m (rms).

NOTE 2 When any test fail, repeat the whole sequence for all temperatures with the optional field strengths if skipped

L.4.1.3 Test report

The test report should include the load modulation amplitudes, the number of passed tests versus the total number of tests, a test description and the number of samples and the date.

L.4.2 Operating field strength test

The operating field strength test for Type A and/or Type B may be combined with the following L.4.3 Communication stability test. Since the operating field strength may be used as an isolated functionality check test, it is specified in a separate clause of this document.

L.4.2.1.1 Purpose

The purpose of this test is to check if the PICC meets the energy performance requirements according to ISO/IEC 14443-2:2001. The PICC should operate as intended within H_{min} and H_{max}, e.g. 1,5 A/m (rms) and 7,5 A/m (rms).

L.4.2.1.2 Test procedure

For this test, it is recommended to have signal patterns that start with the RF off, and then produce an unmodulated field with nominal 13,56 MHz carrier at the field level required by the test for 5 ms prior to modulating this field with the command sequences below. The nominal 13,56 MHz carrier should continue without modulation following the final response of each sequence for a recommended one second.

It is recommended to switch off the carrier for at least 5 ms time before continuing at the next field level and / or bit rate.

The following command sequence has to be executed at least five times for each combination of parameters and each sample:

For Type A the following command sequence has to be executed at least five times for each combination of parameters and each sample:

a) REQA command (see ISO/IEC 14443-3:2001)

b) ANTICOLLISION command (see ISO/IEC 14443-3:2001)

c) SELECT command (see ISO/IEC 14443-3:2001)

d) RATS command (see ISO/IEC 14443-3:2001)

e) PPS command (see ISO/IEC 14443-4:2001)

f) TEST_COMMAND_SEQUENCE1 (see section L.7)

For Type B the following command sequence has to be executed at least five times for each combination of parameters and each sample:

a) REQB command (see ISO/IEC 14443-3:2001)

b) ATTRIB command (see ISO/IEC 14443-3:2001)

c) TEST_COMMAND_SEQUENCE1 (see section L.7)

See section L.7 for a list of possible test command sequences depending on the operation mode, e.g. plain text, BAC, AA, EAC.

Perform the test, according to Figure L.3 — Test procedure for the operating field strength test below, on a minimum of 3 samples at all three temperatures for each combination of parameters from Table L.3 — Specific environment parameters. For PICCs supporting both Type A and Type B repeat the procedure for both types on each sample.

Repeat the test each at temperature and field strength for every supported bit rates of *fc*/128, *fc*/64, *fc*/32, *fc*/16 and at least for both *fc*/128 and *fc*/32.

Table L.3 — Specific environment parameters for operating field strength test

Parameter	Value
Field strength (Mandatory) At temperatures -10 °C and RT	1,5 A/m (rms), 2,5 A/m (rms), 3,5 A/m (rms), 4,5 A/m (rms), 5,5 A/m (rms), 6,5 A/m (rms), 7,5 A/m (rms)
Field strength (Mandatory) At temperatures 50 °C	1,5 A/m (rms), 2,5 A/m (rms), 3,5 A/m (rms), 4,5 A/m (rms), 5,5 A/m (rms), 6,0 A/m (rms)
Bit rate	*fc*/128, *fc*/64, *fc*/32, *fc*/16 [a]
Signal waveform	For Type A: See tables Table L.4 — Fix Parameter Table for bit rates fc/128 and Table L.5 — Fix Parameter Table for bit rates fc/64, fc/32, fc/16 For Type B: See tables Table L.6 — Fix parameter table for bit rates fc/128 and fc/64 and Table L.7 — Fix parameter table for bit rates fc/32 and fc/16
Temperature	-10 °C, RT, 50 °C
[a] All combinations of PICC supported bit rates should be used	

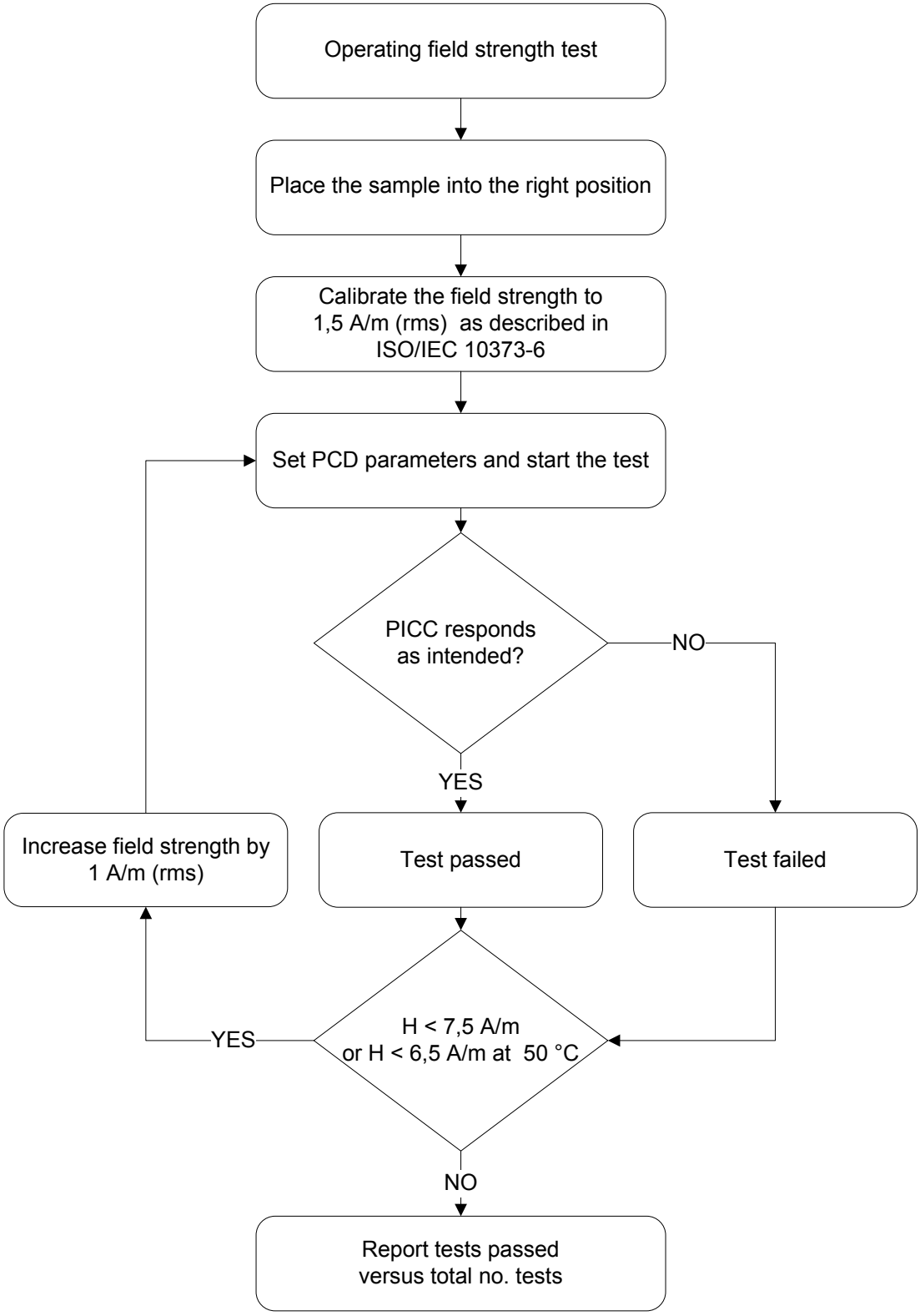

Figure L.3 — Test procedure for the operating field strength test

L.4.2.1.3 Signal waveforms for Type A

Table L.4 — Fix Parameter Table for bit rates fc/128

Parameter	Value
Modulation	100 %
Bit rate	*fc*/128
t_1	3 µs
t_2	0,5 µs
t_3	≤ 1,5 µs
t_4	400 ns
Overshoot	0

Table L.5 — Fix Parameter Table for bit rates fc/64, fc/32, fc/16

Parameter	Values		
Bit rate	*fc*/64	*fc*/32	*fc*/16
A	0,15	0,30	0,55
t_1	20/*fc*	10/*fc*	5/*fc*
t_2	14/*fc*	6/*fc*	3/*fc*
t_3	6/*fc*	6/*fc*	6/*fc*
Overshoot	0	0	0

NOTE 1 For each bit rate, the corresponding table should be taken into account.

NOTE 2 For all bit rates, the sequence of test commands defined above has to be executed at the different magnetic field strengths and temperatures.

L.4.2.1.4 Signal waveforms for Type B

Table L.6 — Fix parameter table for bit rates fc/128 and fc/64

Parameter	Value
Modulation index *m*	12 %
t_r, t_f	≤ 1 µs
h_r, h_f	0

Table L.7 — Fix parameter table for bit rates fc/32 and fc/16

Parameter	Value
Modulation index *m*	12 %
t_r, t_f	≤ 0,8 µs
h_r, h_f	0

L.4.2.2 Test report

The test report should include the number of passed tests versus the total number of tests, a test description and the number of samples and the date.

L.4.3 Communication stability test

L.4.3.1 Purpose

The purpose of this test is to determine the communication stability of Type A and/or Type B versus field strength and rise and fall times according to ISO/IEC 14443-2:2001, ISO/IEC 14443-2:2001/AM1:2005, ISO/IEC 10373-6:2001/AM4:2006 and ISO/IEC 10373-6:2001/AM5:2006.

L.4.3.2 Test setup

For this procedure, the Test PCD assembly has to be used as a PCD antenna. The calibration of the field strength has to be done in advance. Then, the PICC has to be placed at the DUT position. Afterwards, the field strength has to be readjusted.

The high bit rate antenna should be used for testing.

The test PCD assembly (test apparatus) when used with a power amplifier necessary to establish the higher field levels does not have the possibility to test more than a request command. The test apparatus has to be augmented to provide a signal path for the responses to be routed to the controlling apparatus to enable two-way communication. The method used has to be documented in the test report.

Modifications done according:

— Reference ISO/IEC 10373-6:2001/AM2:2006

— Reference ISO/IEC 10373-6:2001/AM4:2006 - PICC reception - Conditions for Type B

— Reference ISO/IEC 10373-6:2001/AM5:2006

— Reference ISO/IEC 14443-2:2001

— Reference ISO/IEC 14443-2:2001/AM1:2005

L.4.3.3 Test procedure

For this test, it is recommended to have signal patterns that start with the RF off, and then produce an unmodulated field with nominal 13,56 MHz carrier at the field level required by the test for 5 ms prior to modulating this field with the command sequences below. The nominal 13,56 MHz carrier should continue without modulation following the final response of each sequence for a recommended one second.

It is recommended to switch off the carrier for at least 5 ms time before continuing at the next field level and / or bit rate.

For Type A the following command sequence has to be executed at least five times for each combination of parameters and each sample:

a) REQA command (see ISO/IEC 14443-3:2001)

b) ANTICOLLISION command (see ISO/IEC 14443-3:2001)

c) SELECT command (see ISO/IEC 14443-3:2001)

d) RATS command (see ISO/IEC 14443-3:2001)

e) PPS command (see ISO/IEC 14443-3:2001)

f) TEST_COMMAND_SEQUENCE1 (see section L.7)

For Type B the following command sequence has to be executed at least five times for each combination of parameters and each sample:

d) REQB command (see ISO/IEC 14443-3:2001)

e) ATTRIB command (see ISO/IEC 14443-3:2001)

f) TEST_COMMAND_SEQUENCE1 (see section L.7)

See for section L.7 for a list of possible test command sequences depending on the operation mode, e.g. plain text, BAC, AA, EAC.

Perform the test, according to Figure L.4 — Test procedure for the communication stability test below on a minimum of 3 samples at all three temperatures. For PICCs supporting both Type A and Type B repeat the procedure for both types on each sample.

At temperatures -10 °C and RT:

— mandatory: 1,5 A/m (rms), 4,5 A/m (rms), 7,5 A/m (rms)

At temperature 50 °C:

— mandatory: 1,5 A/m (rms), 4,5 A/m (rms), 6,0 A/m (rms)

Repeat the test at each temperature and field strength for the bit rates of *fc*/128, *fc*/64, *fc*/32, *fc*/16. For each bit rate apply the corresponding signal waveform as defined in the corresponding tables below. All combinations of PICC supported bit rates should be tested at least for *fc*/128 and *fc*/32.

Table L.8 — Specific environment parameters for communication stability test

Parameter	Value
Field strength (Mandatory) At temperatures -10 °C and RT	1,5 A/m (rms), 4,5 A/m (rms), 7,5 A/m (rms)
Field strength (Mandatory) At temperatures 50 °C	1,5 A/m (rms), 4,5 A/m (rms), 6,0 A/m (rms)
Bit rate	*fc*/128, *fc*/64, *fc*/32, *fc*/16 [a]
Signal waveform	For Type A see tables: L.9 — Test conditions for fc/128 (Type A), L.10 — Test conditions for fc/64 (Type A), L.11 — Test conditions for a bit rate of fc/32 (Type A), L.12 — Test conditions for a bit rate of fc/16 (Type A) For Type B see tables: L.13 — Test conditions for bit rates fc/128 and fc/64 (Type B) L.14 — Test conditions for bit rates fc/32 and fc/16 (Type B)
Temperature	-10 °C, RT, 50 °C
[a] All combinations of PICC supported bit rates should be used	

Table L.9 — Test conditions for fc/128 (Type A)

Condition	*H* A/m (rms)	t_1 µs	t_2 µs	t_3 µs	t_4 µs	modulation %
1	1,5	3	0,5	≤1,5	0,4	95
2	1,5	3	0,5	0,8	0,4	100
3	4,5	3	0,5	≤1,5	0,4	95
4	4,5	3	0,5	0,8	0,4	100
5	7,5	3	0,5	≤1,5	0,4	95
6	7,5	3	0,5	0,8	0,4	100

Table L.10 — Test conditions for fc/64 (Type A)

Condition	*H* A/m (rms)	t_1 µs	t_2 µs	t_3 µs	a
1	1,5	20/*fc*	14/*fc*	6/*fc*	0,2
2	1,5	20/*fc*	16/*fc*	7/*fc*	≤ 0,05
3	4,5	20/*fc*	14/*fc*	6/*fc*	0,2
4	4,5	20/*fc*	16/*fc*	7/*fc*	≤ 0,05
5	7,5	20/*fc*	14/*fc*	6/*fc*	0,2
6	7,5	20/*fc*	16/*fc*	7/*fc*	≤ 0,05

Table L.11 — Test conditions for a bit rate of fc/32 (Type A)

Condition	*H* A/m (rms)	t_1 µs	t_2 µs	t_3 µs	a
1	1,5	10/*fc*	6/*fc*	6/*fc*	0,35
2	1,5	10/*fc*	7/*fc*	7/*fc*	≤ 0,15
3	4,5	10/*fc*	6/*fc*	6/*fc*	0,35
4	4,5	10/*fc*	7/*fc*	7/*fc*	≤ 0,15
5	7,5	10/*fc*	6/*fc*	6/*fc*	0,35
6	7,5	10/*fc*	7/*fc*	7/*fc*	≤ 0,15

Table L.12 — Test conditions for a bit rate of fc/16 (Type A)

Condition	*H* A/m (rms)	t_1 µs	t_2 µs	t_3 µs	a
1	1,5	5/*fc*	3/*fc*	6/*fc*	0,6
2	1,5	5/*fc*	3/*fc*	7/*fc*	≤ 0,3
3	4,5	5/*fc*	3/*fc*	6/*fc*	0,6
4	4,5	5/*fc*	3/*fc*	7/*fc*	≤ 0,3
5	7,5	5/*fc*	3/*fc*	6/*fc*	0,6
6	7,5	5/*fc*	3/*fc*	7/*fc*	≤ 0,3

NOTE 1 For each bit rate, the corresponding table should be taken into account.

NOTE 2 For all bit rates the sequence of test commands defined above has to be executed at the different magnetic field strengths, temperatures and waveforms.

Table L.13 — Test conditions for bit rates fc/128 and fc/64 (Type B)

Condition	*H* A/m (rms)	m %	t_r, t_f µs
1	1,5	8	1
2	1,5	14	1
3	4,5	8	1
4	4,5	14	1
5	7,5	8	1
6	7,5	14	1

Table L.14 — Test conditions for bit rates fc/32 and fc/16 (Type B)

Condition	*H* A/m (rms)	m %	t_r, t_f µs
7	1,5	8	0,8
8	1,5	14	0,8
9	4,5	8	0,8
10	4,5	14	0,8
11	7,5	8	0,8
12	7,5	14	0,8

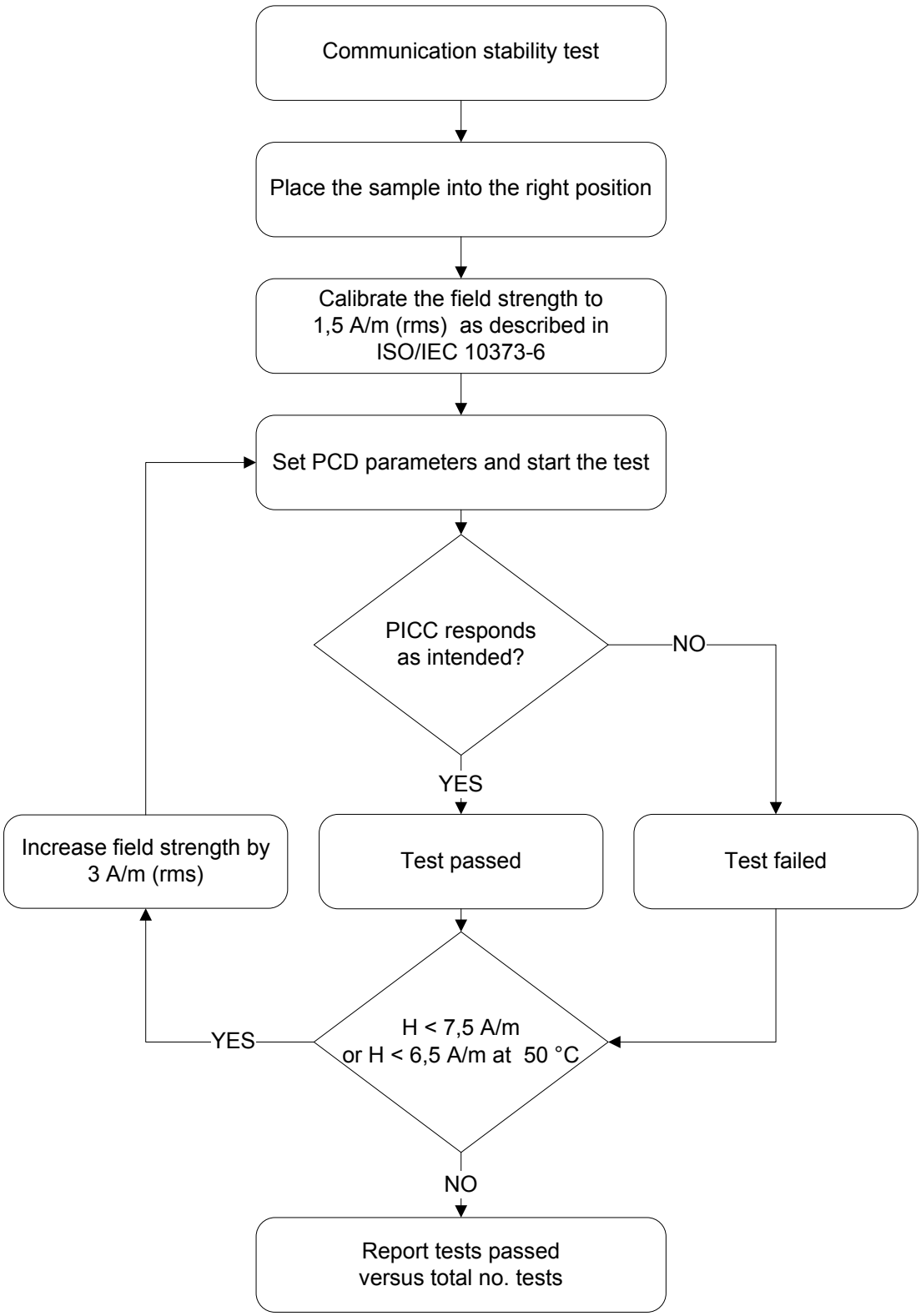

Figure L.4 — Test procedure for the communication stability test

L.4.3.4 Test report

The test report should include the number of passed tests versus the total number of tests, a test description and the number of samples and the date.

L.4.4 Resonance frequency test (optional)

L.4.4.1 Purpose

The purpose of this test is to determine the resonance frequency of the PICC. The resonance frequency should be within the range that has been specified in the implementation conformance specification.

L.4.4.2 Test setup

An LCR meter may be used: a coil that is connected to the device's output generates the magnetic field. The setup should be calibrated in advance. The PICC coil should be positioned in a close distance concentrically above the field-generating coil.

The resonance frequency is defined as the frequency, where the real part of the field generating coil impedance reaches its maximum under threshold conditions of the PICC.

L.4.4.3 Test procedure

Apply ″7.3 PICC resonance frequency (informative)″ on a minimum of 3 samples at RT.

L.4.4.4 Test report

The test report should include all individual test reports of ″7.3 PICC resonance frequency (informative)″ and should state whether the resonance frequencies measured are within the specified range of resonance frequencies.

L.5 Layer 3 timing and framing tests

L.5.1 Test setup

The test setup defined below in this clause should be used for all tests in this section.

The setup as defined for the electrical tests can be used also for timing and framing tests. However, the test laboratory can select an alternative setup for the timing and framing related tests, as long as the setup meets the specified parameters of the test signal. Independently of the selected test setup, the setup is called ″test apparatus″ in this clause.

The test apparatus should be able to emulate the protocol, to measure and monitor the timing of the logical Input/Receive line relative to the carrier frequency, and to be able to analyze the I/O-bit stream in accordance with the protocol.

All tests should be performed at one specific field strength between 1,5 A/m (rms) and 7,5 A/m (rms) if not further specified. All tests should be performed at RT if not further specified.

L.5.2 Start-up time – Polling

L.5.2.1 Type A

L.5.2.1.1 Purpose

The purpose of this test is to check the correct behavior after switching the RF field on and during alternate receiving of REQB and REQA (polling).

L.5.2.1.2 Test procedure

Perform test as defined in Annex G.3.2, on at least 3 samples, at bit rate of *fc*/128.

The PICC should respond to a REQA 10 ms after switching on the RF field and it should respond to a REQA 10 ms after a REQB.

L.5.2.1.3 Test report

The test report should state whether the PICC meets the start-up timing requirements for all samples.

L.5.2.2 Type B

L.5.2.2.1 Purpose

The purpose of this test is to check the correct behavior after switching the RF field on and during alternate receiving of REQB and REQA (polling).

L.5.2.2.2 Test procedure

Perform test as defined in Annex G.4.2, on at least 3 samples, at bit rate of *fc*/128, but change the time parameter in steps 4, 8 and 9 to 10 ms.

The PICC should respond to a REQA 10 ms after switching on the RF field and it should respond to a REQA 10 ms after a REQB.

L.5.2.2.3 Test report

The test report should state whether the PICC meets the start-up timing requirements for all samples.

L.5.3 Frame delay time (Type A only)

L.5.3.1 Purpose

The purpose of this test is to determine the frame delay time (FDT) of the PICC and to check that the Frame Delay Time of the PICC conforms to the value indicated in the FDT column of Table L.15 —FDT values.

L.5.3.2 Test setup

Modifications done according:

— Reference ISO/IEC 14443-3:2001 Frame delay time PCD to PICC

— Reference ISO/IEC 14443-3:2001/AM1:2005

L.5.3.3 Test procedure

Perform test as defined in scenario 2 of Annex G.3.4 on a minimum of 3 samples at *fc*/128. Check the FDT of the PICC response frame.

Depending on the last bit of the command the FDT should be as follows:

Table L.15 —FDT values

Last Bit	FDT
0	1172/*fc*
1	1236/*fc*

L.5.3.4 Test report

The test report should state whether the PICC meets the start-up timing requirements for all samples.

L.5.4 Start-Of-Frame and End-Of-Frame timing (Type B only)

L.5.4.1 Purpose

The purpose of this test is to check whether the PICC meets the SOF and EOF timing requirements according to Annex G.

L.5.4.2 Test procedure

— Perform test for each condition as defined in Annex G.4.3 on three samples at *fc*/128. Set the frame parameters of the test apparatus according to the conditions defined in **Error! Reference source not found.** and **Error! Reference source not found.**.

Table L.16 — SOF test conditions

Condition	**SOF "0"** etu	**SOF "1"** etu
1	10	2
2	11	3

Table L.17 — EOF test conditions

Condition	**EOF** etu
1	10
2	11

Check the values SOF and EOF of the PICC response frame.

The values of SOF and EOF should conform to the following:

— SOF logic 0 timing should be between 10 and 11 etu.

— SOF logic 1 timing should be between 2 and 3 etu.

— EOF logic 0 timing should be between 10 and 11 etu.

L.5.4.3 Test report

The test report should state whether the PICC meets the SOF and EOF timing requirements for all samples.

L.5.5 Extra guard time (Type B only)

L.5.5.1 Purpose

The purpose of this test is to check whether the PICC meets the EGT timing requirements according to ISO/IEC 14443-3:2001.

L.5.5.2 Test procedure

Perform test for each condition as defined in Annex G.4.3 on three samples at *fc*/128. Set the frame parameters of the test apparatus according to the conditions defined in Table L.18 — EGT test conditions.

Table L.18 — EGT test conditions

Condition	EGT etu
1	1
2	3,4
3	6

Check, that the values of the EGT of the PICC response frame are equal or greater than 0 etu and less or equal than 2 etu.

L.5.5.3 Test reports

The test report should state whether the PICC meets the requirements concerning EGT timing for all samples.

L.5.6 Timing before PICC SOF (TR0 and TR1) (Type B only)

L.5.6.1 Purpose

The purpose of this test is to check whether the PICC meets the TR0 and TR1 requirements according to ISO/IEC 14443-3:2001.

L.5.6.2 Test procedure

Perform test as defined in Annex G.4.3 on three samples at *fc*/128. Check the values of TR0 and TR1 before PICC SOF.

TR0 and TR1 should be between the minimum and maximum values defined in Table L.19 — TR0 and TR1 boundaries.

Table L.19 — TR0 and TR1 boundaries

	Min	Max
TR0	64/fs	256/fs
TR1	80/fs	200/fs

L.5.6.3 Test reports

The test report should state whether the PICC meets the requirements concerning TR0 and TR1 timing for all samples.

L.5.7 Timing after PICC EOF (subcarrier turn-off time) (Type B only)

L.5.7.1 Purpose

The purpose of this test is to check whether the PICC meets the subcarrier turn-off time after PICC EOF.

L.5.7.2 Test procedure

Perform test as defined in Annex G.4.3 on three samples at *fc*/128. Check the subcarrier turn-off time.

The PICC should turn off the subcarrier between 0 and 2 etu after PICC EOF.

L.5.7.3 Test reports

The test report should state whether the PICC meets the requirements concerning subcarrier turn-off time after PICC EOF timing for all samples.

L.5.8 Timing after PICC EOF (TR2) (Type B only)

L.5.8.1 Purpose

The purpose of this test is to check whether the PICC meets the minimum TR2 timing requirement as defined in the protocol byte of the PICC's ATQB, see ISO/IEC 14443-3:2001 [6], its amendment 1 [9] and the corresponding defect report [11].

L.5.8.2 Test procedure

Perform the test as follows on three samples at *fc*/128:

a) Place the PICC into the field.

b) Set the frame parameters of the test apparatus according to Table G.31 — Type B specific timing table and Table L.1 — Nominal values.

c) Send REQB(0).

d) After the ATQB do a delay of minimum TR2 as defined in [11].

e) Send ATTRIB(0,0) command.

f) Record the presence, contents and timings of the PICC responses.

The PICC's response to the ATTRIB command should be a valid Answer to ATTRIB.

L.5.8.3 Test reports

The test report should state whether the PICC meets the minimum TR2 timing requirement for all samples.

L.6 Layer 3 and 4 protocol tests

These tests provide a basic set of tests to be performed to check the compliance to ISO/IEC 14443 protocol layers 3 and 4 ([6] ISO/IEC 14443-3:2001, ISO/IEC 14443-3:2001/AM1:2005 and ISO/IEC 14443-4:2001). All tests are based on and should be evaluated according to the referenced versions of standards.

L.6.1 Test setup

The setup as defined for the electrical tests can be used also for protocol tests. However, the test laboratory can select an alternative setup for the protocol related tests, as long as the setup meets the specified parameters of the test signal. Independently of the selected test setup, the setup is called "test apparatus" in this clause.

The test apparatus should be able to emulate the protocol, to measure and monitor the timing of the logical Input/Receive line relative to the carrier frequency, and to be able to analyze the I/O-bit stream in accordance with the protocol.

All tests should be performed with one specific field strength between 1,5 A/m (rms) and 7,5 A/m (rms) if not further specified. All tests should be performed at RT if not further specified.

For the test, commands that are typical for an application should be used. Therefore, refer to L.7 List of test command sequences (informative) for a list of TEST COMMANDS that should be used for testing the PICC.

For PICCs conforming both to Type A and Type B, both L.6.2 Type A activation L.6.3 Type B activation should be performed.

RFU fields should be constantly monitored during the testing and should always be verified to contain the assigned default value in accordance with Annex G.1.5.

L.6.2 Type A activation

These tests should ensure that the start-up and the activation of a Type A PICC are in accordance with ISO/IEC 14443-3:2001. These tests are split up to state transitions and the handling of RATS and PPS.

L.6.2.1 State transitions

L.6.2.1.1 Purpose

The purpose of this test is to check the correct behavior during state transitions as defined in ISO/IEC 14443-3:2001. Additionally possible proprietary paths of the "Select sequence flow chart" specified in ISO/IEC 14443-3:2001 should not negatively affect the test.

L.6.2.1.2 Test procedure

Perform test as defined Annex G.3.4. The tests specified in the sub-clause "Testing of the PICC Type A state transitions" of ISO/IEC 10373-6:2001/AM1:2006 should be used. The detailed test procedure is not specified further herein.

L.6.2.1.3 Test report

The test report should state whether the PICC responds as indicated in the procedures.

L.6.2.2 Handling of Type A anticollision

L.6.2.2.1 Purpose

The purpose of this test is to check the correct behavior during anticollision as defined in ISO/IEC 10373-6:2001/AM1:2006.

L.6.2.2.2 Test procedure

Perform test as defined Annex G.3.5. The tests specified in the sub-clause ″Handling of type A anticollision″ of ISO/IEC 10373-6:2001/AM1:2006 should be used. The detailed test procedure is not specified further herein.

L.6.2.2.3 Test report

The test report should state whether the PICC responds as indicated in the procedures.

L.6.2.3 Handling of RATS

L.6.2.3.1 Purpose

The purpose of this test is to check the correct behavior of RATS as defined in ISO/IEC 14443-4:2001.

L.6.2.3.2 Test procedure

Perform test as defined in ISO/IEC 10373-6:2001/AM1:2006, Annex G.3.6. The tests specified in the sub-clause ″Handling of RATS″ should be used. The detailed test procedure is not specified further herein.

In addition, it should be verified if the bit rates as defined in the interface byte TA(1) of the ATS are equal to the bit rates claimed in the implementation conformance statement.

L.6.2.3.3 Test report

The test report should state whether the PICC responds as indicated in the procedures. It should state if the ATS correctly encodes the bit rates.

L.6.2.4 Handling of PPS

L.6.2.4.1 Purpose

The purpose of this test is to check the correct behavior of RATS as defined in ISO/IEC 14443-4:2001.

L.6.2.4.2 Test procedure

Perform test as defined Annex G.3.7. The tests specified in the sub-clause ″Handling of PPS request″ should be used. The detailed test procedure is not specified further herein.

Test Scenario 17: PPS without PPS1 as defined in ISO/IEC 10373-6:2001/AM1:2006 should not be performed.

L.6.2.4.3 Test report

The test report should state whether the PICC responds as indicated in the procedures.

L.6.2.5 Handling of FSD

L.6.2.5.1 Purpose

The purpose of this test is to check if the PICC correctly handles FSD negotiated by the RATS as defined in ISO/IEC 14443-4:2001.

L.6.2.5.2 Test procedure

Perform test as defined Annex G.3.8. The tests specified in the sub-clause ″Handling of FSD″ of should be used. The detailed test procedure is not specified further herein.

L.6.2.5.3 Test report

The test report should state whether the PICC responds as indicated in the procedures.

L.6.3 Type B activation

These tests should ensure that the start-up and the activation of a Type B PICC are in accordance with ISO/IEC 14443-3:2001.

L.6.3.1 State transitions

L.6.3.1.1 Purpose

The purpose of this test is to verify the correct implementation of a Type B PICC's state machine.

L.6.3.1.2 Test procedure

Perform test as defined in Annex G.4.4 ″Testing of the PICC Type B State Transition″.

L.6.3.1.3 Test report

The test report should state whether the PICC responds as indicated in the procedures.

L.6.3.2 Handling of Type B anticollision

L.6.3.2.1 Purpose

The purpose of this test is to verify the handling of a PICC Type B anticollision.

L.6.3.2.2 Test procedure

Perform test as defined in Annex G.4.5 ″Handling of Type B Anticollision″.

L.6.3.2.3 Test report

The test report should state whether the PICC responds as indicated in the procedures.

L.6.3.3 Handling of ATTRIB

L.6.3.3.1 Purpose

The purpose of this test is to verify the behavior of the PICC Type B on ATTRIB command.

L.6.3.3.2 Test procedure

Perform test as defined in Annex G.4.6 ″Handling of ATTRIB″. In addition, it should be verified if the bit rates as defined in the protocol info byte of the ATQB are equal to the bit rates claimed in the implementation conformance statement.

L.6.3.3.3 Test report

The test report should state whether the PICC responds as indicated in the procedures . It should state if the ATQB correctly encodes the bit rates.

L.6.3.4 Handling of maximum frame size

L.6.3.4.1 Purpose

The purpose of this test is to check if the PICC correctly handles FSD negotiated by the ATTRIB as defined in ISO/IEC 14443-3:2001.

L.6.3.4.2 Test procedure

Perform test as defined in Annex G.4.7 ″Handling of Maximum Frame Size″.

L.6.3.4.3 Test report

The test report should state whether the PICC responds as indicated in the procedures.

L.6.4 Data exchange protocol tests

These tests should ensure the logical operation is in accordance with ISO/IEC 14443-4:2001. They are valid for both, Type A and Type B, whereas the activation before running these tests is different and listed below.

L.6.4.1 Test procedure

All tests should be performed with one specific field strength between 1,5 A/m (rms) and 7,5 A/m (rms) if not further specified. All tests should be performed at RT if not further specified.

The activation for Type A should be:

a) Activation using: REQA, ANTICOLLISION, SELECT commands (as defined in ISO/IEC 14443-3:2001).

b) Activation using: RATS command (as defined in ISO/IEC 14443-4:2001).

c) Check that activation has been correct (response has been correct for all commands).

The activation for Type B should be:

a) Activation using: REQB command with number of timeslots set to 0 (as defined in ISO/IEC 14443-3:2001).

b) Activation using: ATTRIB command (as defined in ISO/IEC 14443-3:2001).

c) Check that activation has been correct (response has been correct for all commands).

L.6.4.2 Exchange of I-blocks

L.6.4.2.1 Purpose

The purpose of this test is to check the correct behavior of I-blocks as defined in ISO/IEC 14443-4:2001.

L.6.4.2.2 Test procedure

Perform tests as defined in Annex G.5.2. These tests include both correct and erroneous transactions and are described in ISO/IEC 10373-6:2001/AM1:2006 and with the scenario caption ″Exchange of I-blocks″. The general TEST_COMMAND1 as defined by ISO/IEC 10373-6:2001/AM1:2006 is specified in L.7 List of test command sequences (informative). The detailed test procedure is not specified further herein.

L.6.4.2.3 Test report

The test report should state whether the response is in accordance with ISO/IEC 14443-4:2001. The report should include the test commands used.

L.6.4.3 Chaining of I-blocks

L.6.4.3.1 Purpose

The purpose of this test is to check the correct behavior of chained I-blocks as defined in ISO/IEC 14443-4:2001. These tests are divided into two parts, the first one where the PCD (test apparatus) uses chaining and the second one where the PICC uses chaining.

L.6.4.3.2 PCD uses chaining

L.6.4.3.2.1 Purpose

The PCD chaining tests can be performed without knowing dedicated command behavior on the device under test. The purpose of this test is to check the correct behavior of chained I-blocks from PCD side as defined in [7].

L.6.4.3.2.2 Test procedure

Perform tests as defined in Annex G.5.2. These tests include both correct and erroneous transactions and are described in [7] and with the scenario caption ″PCD uses chaining″. The general TEST_COMMAND1 is specified in L.7 List of test command sequences (informative). The detailed test procedure is not specified further herein.

L.6.4.3.2.3 Test report

The test report should state whether the response is in accordance with [7]. The report should include the test commands used.

L.6.4.3.3 PICC uses chaining (optional)

L.6.4.3.3.1 Purpose

The purpose of this test is to check the correct behavior of chained I-blocks from PICC side as defined in ISO/IEC 14443-4:2001.

L.6.4.3.3.2 Test procedure

Perform tests as defined in Annex G.5.2. These tests include both correct and erroneous transactions and are described in ISO/IEC 14443-4:2001 and with the scenario caption ″PICC uses chaining″. If applicable, the general TEST_COMMAND2 is specified in L.7 List of test command sequences (informative). The detailed test procedure is not specified further herein.

L.6.4.3.3.3 Test report

The test report should state whether the response is in accordance with ISO/IEC 14443-4:2001. The report should include the test commands used.

L.6.4.4 DESELECT

L.6.4.4.1 Purpose

The purpose of this test is to check the correct behavior of DESELECT command as defined in ISO/IEC 14443-4:2001.

L.6.4.4.2 Test procedure

Perform tests as defined in Annex G.5.2. These tests include both correct and erroneous transactions and are described in ISO/IEC 14443-4:2001 and with the scenario caption ″DESELECT″. The general TEST_COMMAND1 is specified in L.7 List of test command sequences (informative). The detailed test procedure is not specified further herein.

L.6.4.4.2.1 Test report

The test report should state whether the response is in accordance with ISO/IEC 14443-4:2001. The report should include the test commands used.

L.6.4.5 Request for waiting time extension (optional)

L.6.4.5.1 Purpose

The purpose of this test is to check the correct behavior of request waiting time extension command as defined in ISO/IEC 14443-4:2001.

If the PICC does not support a command, which by default responds with a waiting time extension, this test cannot be performed. Therefore, it is optional. This test should be performed if waiting time extension support is claimed in the conformance form.

L.6.4.5.2 Test procedure

Perform tests as defined in Annex G.5.2. These tests include both correct and erroneous transactions and are described in [7] and with the scenario caption ″Request for waiting time extension″. The general TEST_COMMAND3 is specified in L.7 List of test command sequences (informative) which by default responds with the waiting time extension command. The detailed test procedure is not specified further herein.

L.6.4.5.2.1 Test report

The test report should state whether the response is in accordance with [7]. The report should include the test commands used.

L.6.4.6 Handling of PICC error detection (optional)

L.6.4.6.1 Purpose

The purpose of this test is to check the correct behavior of the PICC's error detection as defined in defined in [7].

L.6.4.6.2 Test procedure

Perform tests as defined in Annex G.5.3. These tests include both correct and erroneous transactions and are described in ISO/IEC 14443-4:2001 and with the scenario caption ″Handling of PICC error detection″. The general TEST_COMMAND1 and TEST_COMMAND3 are specified in L.7 List of test command sequences (informative) which by default responds with the waiting time extension command. The detailed test procedure is not specified further herein.

L.6.4.6.3 Test report

The test report should state whether the response is in accordance with [7]. The report should include the test commands used.

L.6.4.7 PICC reaction on CID

L.6.4.7.1 Purpose

The purpose of this test is to check the correct reaction of the PICC to CID coding as defined in [7]. This test can be applied to all PICCs even if they do not support CID.

L.6.4.7.2 Test procedure

Perform tests as defined in Annex G.5.4. The general TEST_COMMAND1, TEST_COMMAND2 and TEST_COMMAND3 are specified in L.7 List of test command sequences (informative). The detailed test procedure is not specified further herein.

L.6.4.7.3 Test report

The test report should state whether the response is in accordance with [7]. The report should include the test commands used.

L.7 List of test command sequences (informative)

This section contains sequences of test commands on the application level that are employed in several test cases defined in this technical report, e.g. chaining in the frame protocol layer. Since the ISO/IEC 10373-6/Amd.1:2007 does only define generic test commands, this section provides mandatory test commands that are specific to the PICC's LDS application and its variants.

L.7.1 Test commands for PICC without access control (plain)

L.7.1.1 TEST_COMMAND_SEQUENCE1

TEST_COMMAND_SEQUENCE1 is the sequence of commands, used for tests described in clauses below:

— Operating field strength test, clause L.4.2.

— Communication stability test, clause L.4.3.

TEST_COMMAND_SEQUENCE1 should come after:

— PICC activation process described in G.7.1.1. (RATS and PPS / ATTRIB are successfully performed).

APDU definition:

Step	Command	C-APDU
1	SELECT	00 A4 04 0C 07 A0 00 00 02 47 10 01
2	READ BINARY	00 B0 81 00 00

L.7.1.2 TEST_COMMAND1

TEST_COMMAND1 is the basic command, used for tests described in clauses below:

— Exchange of I-blocks, clause L.6.4.2.

— Chaining of I-blocks, clause L.6.4.3.

— DESELECT, clause L.6.4.4.

— Handling of PICC error detection, clause L.6.4.6.

— PICC reaction on CID, clause L.6.4.7.

TEST_COMMAND1 should come after:

— PICC activation process described in G.7.1.1. should be performed (RATS and PPS / ATTRIB are successfully performed).

APDU definition:

Step	Command	C-APDU
1	SELECT	00 A4 04 0C 0C A0 00 00 02 47 10 01 00 00 00 00 00[a]
[a] The application will not process this command successfully but it can be used for PCD chaining.		

L.7.1.3 TEST_COMMAND2

TEST_COMMAND2 is the basic command, used for tests described in clauses below:

— Chaining of I-blocks, clause L.6.4.3.

— Handling of PICC error detection, clause L.6.4.6.

TEST_COMMAND2 should come after:

— PICC activation process described in G.7.1.1. should be performed (RATS and PPS / ATTRIB are successfully performed).

— LDS application (AID = ″A0 00 00 02 47 10 01″) is successfully selected

APDU definition:

Step	Command	C-APDU
1	READ BINARY	00 B0 82 00 00

L.7.1.4 TEST_COMMAND3

TEST_COMMAND3 is the basic command, used for tests described in clauses below:

— Request for waiting time extension (optional), clause L.6.4.5.

— Handling of PICC error detection, clause L.6.4.6.

— PICC reaction on CID, clause L.6.4.7.

APDU definition:

— To be defined by applicant.

L.7.2 Test commands for PICC with BAC

L.7.2.1 TEST_COMMAND_SEQUENCE1

TEST_COMMAND_SEQUENCE1 is the sequence of commands, used for tests described in clauses below:

— Operating Field Strength Test, clause L.4.2.

— Communication Stability Test, clause L.4.3.

TEST_COMMAND_SEQUENCE1 should come after:

— PICC activation process described in G.7.1.1. should be performed (RATS and PPS / ATTRIB are successfully performed).

APDU definition:

Step	Command	C-APDU
1	SELECT	00 A4 04 0C 07 A0 00 00 02 47 10 01
2	GET CHALLENGE	00 84 00 00 08
3	MUTUAL AUTHENTICATE	00 82 00 00 28 <authentication token> 28
4	READ BINARY	0C B0 81 00 0D 97 01 00 8E 08 <mac> 00

L.7.2.2 TEST_COMMAND1

TEST_COMMAND1 is the basic command, used for tests described in clauses below:

— Exchange of I-blocks, clause L.6.4.2.

— Chaining of I-blocks, clause L.6.4.3.

— DESELECT, clause L.6.4.4.

— Handling of PICC error detection, clause L.6.4.6.

— PICC reaction on CID, clause L.6.4.7.

TEST_COMMAND1 should come after:

— PICC activation process described in G.7.1.1. should be performed (RATS and PPS / ATTRIB are successfully performed).

APDU definition:

Step	Command	C-APDU
1	SELECT	00 A4 04 0C 0C A0 00 00 02 47 10 01 00 00 00 00 00[a]
[a] The application will not process this command successfully but it can be used for PCD chaining.		

L.7.2.3 TEST_COMMAND2

TEST_COMMAND2 is the basic command, used for tests described in clauses below:

— Chaining of I-blocks, clause L.6.4.3.

— Handling of PICC error detection, clause L.6.4.6.

TEST_COMMAND2 should come after:

— PICC activation process described in G.7.1.1. should be performed (RATS and PPS / ATTRIB are successfully performed).

— LDS application ″A0 00 00 02 47 10 01″ is successfully selected

— Basic access is granted

APDU definition:

Step	Command	C-APDU
1	READ BINARY	0C B0 82 00 0D 97 01 00 8E 08 <mac> 00

L.7.2.4 TEST_COMMAND3

TEST_COMMAND2 is the basic command, used for tests described in clauses below:

— Request for waiting time extension (optional), clause L.6.4.5.

— Handling of PICC error detection, clause L.6.4.6.

— PICC reaction on CID, clause L.6.4.6.

APDU definition:

— To be defined by applicant.

L.7.3 Test commands for PICC with AA

L.7.3.1 TEST_COMMAND_SEQUENCE1

TEST_COMMAND_SEQUENCE1 is the sequence of commands, used for tests described in clauses below:

— Operating Field Strength Test, clause L.4.2.

— Communication Stability Test, clause L.4.3.

TEST_COMMAND_SEQUENCE1 should come after:

— PICC activation process described in G.7.1.1. should be performed (RATS and PPS / ATTRIB are successfully performed).

APDU definition:

Step	Command	C-APDU
1	SELECT	00 A4 04 0C 07 A0 00 00 02 47 10 01
2	INTERNAL AUTHENTICATE	00 88 00 00 08 F1 73 58 99 74 BF 40 C6 00

L.7.3.2 TEST_COMMAND1

See TEST_COMMAND1 in clause L.7.1.2.

L.7.3.3 TEST_COMMAND2

See TEST_COMMAND2 in clause L.7.1.3.

L.7.3.4 TEST_COMMAND3

See TEST_COMMAND3 in clause L.7.1.4.

L.7.4 Test commands for PICC with BAC+AA

L.7.4.1 TEST_COMMAND_SEQUENCE1

TEST_COMMAND_SEQUENCE1 is the sequence of commands, used for tests described in clauses below:

— Operating Field Strength Test, clause L.4.2.

— Communication Stability Test, clause L.4.3.

TEST_COMMAND_SEQUENCE1 should come after:

— PICC activation process described in G.7.1.1. should be performed (RATS and PPS / ATTRIB are successfully performed).

APDU definition:

Step	Command	C-APDU
1	SELECT	00 A4 04 0C 07 A0 00 00 02 47 10 01
2	INTERNAL AUTHENTICATE	00 88 00 00 08 F1 73 58 99 74 BF 40 C6 00

L.7.4.2 TEST_COMMAND1

TEST_COMMAND1 is the basic command, used for tests described in clauses:

— Exchange of I-blocks, clause L.6.4.2.

— Chaining of I-blocks, clause L.6.4.3.

— DESELECT, clause L.6.4.4.

— Handling of PICC error detection, clause L.6.4.6.

— PICC reaction on CID, clause L.6.4.7.

TEST_COMMAND1 should come after:

— PICC activation process described in G.7.1.1. should be performed (RATS and PPS / ATTRIB are successfully performed).

APDU definition:

Step	Command	C-APDU
1	SELECT	00 A4 04 0C 0C A0 00 00 02 47 10 01 00 00 00 00 00[a]
[a] The application will not process this command successfully but it can be used for PCD chaining.		

L.7.4.3 TEST_COMMAND2

TEST_COMMAND2 is the basic command, used for tests described in clauses below:

— Chaining of I-blocks, clause L.6.4.3.

— Handling of PICC error detection, clause L.6.4.6.

TEST_COMMAND2 should come after:

— PICC activation process described in G.7.1.1. should be performed (RATS and PPS / ATTRIB are successfully performed).

— LDS application ″A0 00 00 02 47 10 01″ is successfully selected

— Basic access is granted

APDU definition:

Step	Command	C-APDU
1	READ BINARY	0C B0 82 00 0D 97 01 00 8E 08 <mac> 00

L.7.4.4 TEST_COMMAND3

TEST_COMMAND3 is the basic command, used for tests described in clauses below:

— Request for waiting time extension (optional), clause L.6.4.5.

— Handling of PICC error detection, clause L.6.4.6.

— PICC reaction on CID, clause L.6.4.7.

APDU definition:

— To be defined by applicant.

L.8 Functionality check test (informative)

L.8.1 Purpose

For destructive tests such as mechanical and electrical (layer 1) stress tests, it is often required to check if the PICC ″operates as intended″. These tests are not defined further by the ISO/IEC standards, and thus they are left to the responsibility of the test laboratories.

Since there may be different requirements for performing functionality check tests, this section specifies two optional tests to verify the PICCs functionality on the electrical and on the application level without performing all these, sometimes time-consuming tests specified in this technical report.

On the electrical level, the functionality check tests require specialized equipment and may only be performed by test laboratories that have the necessary skills and equipment, whereas the application functionality check test may be performed with standard equipment.

L.8.1.1 Optional Procedure 1: Application functionality check test

L.8.1.1.1 Purpose

This test is a basic functionality check test.

The purpose of this test is to check if the PICC's mandatory LDS application data as specified in ″Technical Report: Development of a Logical Data Structure - LDS for optional capacity expansion technologies, version 1.7″ can be retrieved from the PICC. It has to be verified that this information has not been altered by the destructive tests.

L.8.1.1.2 Test setup

The test may be performed with standard PC/SC readers and any software that is able to send commands to the PICC and that can verify the integrity of the data retrieved.

L.8.1.1.3 Test procedure

The test procedure should be performed with all given samples as follows:

a) Put the PICC on the contactless reader of the tests setup.

b) Select the PICC using the initialization and anticollision procedure defined in [6].

c) Select the LDS application as specified in [1]

d) Perform basic access control as specified in [2] if indicated in the implementation conformance statement.

e) Read data of file EF.COM as specified in [1].

f) Read data of file EF.DG1 as specified in [1].

g) Read data of file EF.DG2 as specified in [1].

h) Read the document security object of file EF.SOD as specified in [1].

i) Verify the digital signature contained in the document security object as specified in [2].

L.8.1.1.4 Test report

The test report should state whether the defined LDS application data can be retrieved and whether the data has been altered.

L.8.1.2 Optional Procedure 2: Electrical functionality check test

L.8.1.2.1 Purpose

The purpose of this test is to check the electrical functionality of the PICC and may be used in addition to the Optional Procedure 1: Application functionality check test specified in sub clause L.8.1.1.

L.8.1.2.2 Test setup

For this test, the test setup defined in the corresponding tests should be used.

L.8.1.2.3 Test procedure

The test procedure should be performed with all given samples using at least one of the following methods:

— Apply the Resonance Frequency Test as specified in clause L.4.4.

— Apply the Operating Field Strength Test as specified in clause L.4.2.

— Apply an alternative method comparing relative values of the threshold field strength before and after the mechanical or electrical stress test.

L.8.1.2.4 Test report

The test report should state whether the resonance frequency is in the range specified in the implementation conformance statement or whether the PICC operates as intended for all combinations of temperatures and field strengths, see clause L.4.2.

L.9 Bibliography

The following documentation serves as a reference for this annex:

[1] Technical Report: Development of a Logical Data Structure – LDS for optional capacity expansion technologies, version 1.7

[2] Technical Report: PKI for Machine Readable Travel Documents offering ICC Read-Only access, version 1.1

[3] RFC 2119, S. Bradner, "Key Words for Use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, March 1997

[4] ISO/IEC 14443-1:2000, Proximity Cards: Physical Characteristics

[5] ISO/IEC 14443-2:2001, Proximity Cards: Radio Frequency Power and Signal Interface

[6] ISO/IEC 14443-3:2001, Proximity Cards: Initialization and Anticollision

[7] ISO/IEC 14443-4:2001, Proximity Cards: Transmission protocol

[8] ISO/IEC 14443-2:2001/AM1:2005, Proximity Cards: Radio Frequency Power and Signal Interface (Amendment 2: Bit Rates of *fc*/64, *fc*/32 and *fc*/16)

[9] ISO/IEC 14443-3:2001/AM1:2005, Proximity Cards: Initialization and Anticollision (Amendment 1: Bit Rates of *fc*/64, *fc*/32, and *fc*/16)

[10] ICAO Doc 9303 Part 1 Volume 2, 6th edition, 2005.

[11] Defect Report and Technical Corrigendum 1 for - International Standard ISO/IEC 14443-3:2001/AM1: Identification cards – Contactless integrated circuit(s) cards – Proximity cards – Part 3: initialization and anticollision – Amendment 1: Bit rates for *fc*/64, *fc*/32 and *fc*/16

Annex M
(informative)

PCD test methods

M.1 Scope

This annex defines a test plan for the contactless part of the e-Passport PCD. These tests are divided into tests of the electrical parameters, according to ISO/IEC 14443-2:2001:2001 and tests of the initialisation & anticollision and the frame protocol according to ISO/IEC 14443-3:2001:2001 and ISO/IEC 14443-4:2001:2001.

In order for the PCD to operate correctly, many functional layers of technology should work together. The purpose of this annex is to define in depth the tests to be performed to minimize the probability that an error or fault remain undetected before the design is approved.

For PCD compliance testing, this annex is interpreted as mandatory.

M.2 Terms, definitions and abbreviations

For the purpose of this annex, the terms and definitions of ISO/IEC 14443-2:2001, ISO/IEC 14443-3:2001, ISO/IEC 14443-4:2001 and the following definitions apply.

LMA	Load modulation amplitude
Sample	A sample is one piece of the total number of PICCs required and presented for testing according to this specification
Room temperature	Room temperature (RT) is defined as any convenient temperature within the range of 23 °C ± 3 °C (73 °F ± 5 °F).

M.3 General Test Requirements

Following sub-clauses specify the different test setups, the nominal values used for the tests and a recommendation of the report.

Tests for bit rates of *fc*/128 and *fc*/32 are mandatory and should be applied. All other supported bit rates should also be tested.

The PCD should support asymmetric communication speeds from/to the PICC if offered by the PICC to minimize transaction time.

The tolerance for the resonance frequency of the Reference PICC is ± 2 %.

All given temperature values may have a tolerance value of ± 0,5 °C.

All other value may have a tolerance value as specified in the base standards.

M.3.1 Test procedure

The PCD assembly (test apparatus) that is defined in this standard is the basis for the physical and electrical tests. This test apparatus is used to calibrate the Reference PICC that is defined in ISO/IEC 10373-6:2001 clause 6.3.

In addition to what is required by the base test standard, the samples should provide the features as described in clause M.3.3. The manufacturer provides a description how to switch the sample into the test mode and how to operate the sample for the test cases described in this document.

M.3.2 Implementation conformance statement

In order to set up the tests properly, an applicant should provide the information specified in Table M.1 — Test precondition table ″Information on the product″.

Table M.1 — Test precondition table ″Information on the product″

Information for test setup	Applicant declaration
PCD class	
Bit rates supported by the PCD • 106 kbit/sec • 212 kbit/sec • 424 kbit/sec • 848 kbit/sec	
Access control supported • Plaintext • Basic Access Control • Extended Access Control	
Authentication supported • Passive Authentication • Active Authentication	
Operating temperature range	

M.3.3 PCD test features

The test apparatus should be capable of sending contiguous activation commands. For Type A, these commands are REQA, AC, SELECT, RATS, and PPS. For Type B, these are REQB, the optional Slot-MARKER, and ATTRIB. If there is no response from the PICC, the communication type should be changed and the activation procedure should start from the beginning. If this is not possible, the dedicated commands should be available to expose all commands to the upper tester. Therefore, it is possible to start each command from host side if necessary.

Additionally the ISO/IEC 14443-4:2001 command set should be available to exchange data. It should also be possible to receive chained data, e.g. BlockExchange.

Errors should be handled in the PCD and not in the upper tester or host. If possible, the final operating system should be tested.

For synchronization purposes the PCD may provide a test pin output. The test apparatus may also be synchronized by probing the backscattered signal using an ISO pickup coil. This pickup coil should not influence the field significantly.

The applicant may provide the PCD test interface specified in M.7 Measurement points.

M.3.4 Nominal values

Unless otherwise specified, the environment parameters and nominal values defined in Table M.2 — Environment parameters should be used:

Table M.2 —Environment parameters

Parameter	Value	Applies to
Environment temperature	23 °C ± 3 °C (73 °F ± 5 °F)	Type A and B
Relative humidity	25 % to 75 %	Type A and B

Tests have to be done at the same temperature range as the PICC tests (-10 °C … 50 °C). The customer is free to specify a limited range (for example for indoor systems) in the implementation conformance statement.

M.3.5 Definition of measurement points

All layer 2 tests should be performed over a certain set of points within the defined volume.

Volume definition:

Clause M.7 Measurement points″ specifies volume dimensions, so called ″PCD design types″. If due to the construction and/or normal use of the PCD other dimension sizes are recommended by the manufacturer of the PCD, the test institute should check if these dimension sizes are appropriate and define the dimensions of the volume accordingly.

Volume location:

The PCD manufacturer should define the position of the volume in the technical documentation of the PCD. The volume should be located with one surface exactly on the surface of the PCD.

Alternatively, the volume may be located within the PCD. In this case, the volume size definition should be adopted accordingly.

PCDs may be tested inside of their housing, exactly as they are used in border control applications.

Applying the PCD type concept, it is required to consider mechanical and optical constraints specific to a PCD. The test may be adapted to match these constraints. The report should state the specific operating conditions during a particular test.

Measurement points:

Clause M.7 Measurement points specifies measurement points.

Height Z = 0 mm: The measuring antenna should be placed exactly at the bottom of the volume (at the surface of the scanner plate, if appropriate).

Height Z = x mm: The top surface of the test antenna should be located in a distance of x mm of the bottom of the volume (in a distance of x mm from the surface of the scanner plate, if appropriate).

M.3.6 Definition of the Reference PICC for load modulation reception test

The Reference PICC introduced for the load modulation reception test is based on Annex E with improved functionality.

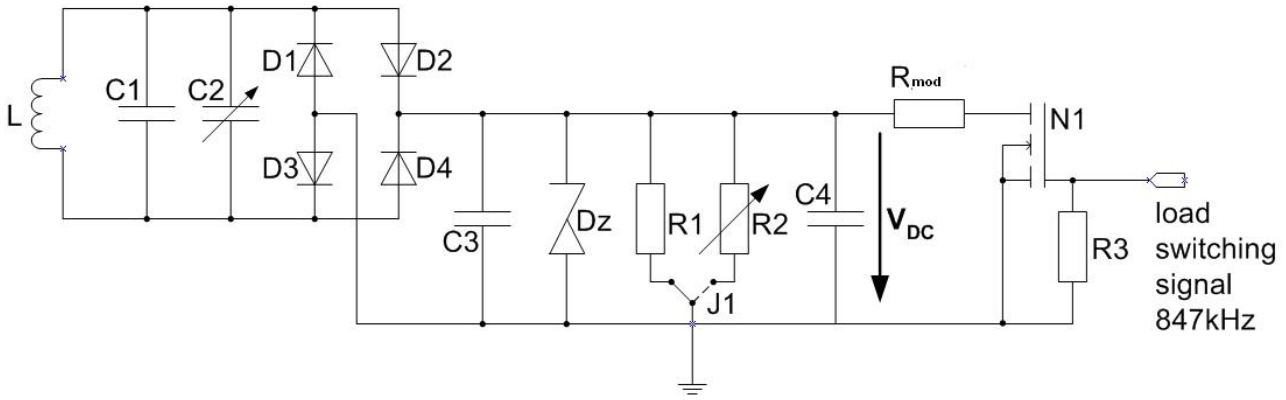

Figure M.1 — Reference PICC

The signal at pin 'load switching signal 847 kHz' should have an amplitude value between 0 and 4 V, for stable switching of the recommended transistor. In order to reduce common-mode current, a balun may be used between the signal generator and the Reference PICC.

Table M.3 — Reference PICC

Component	Value
L	See clause 6.3.5
R1	4,3 kΩ
R2	Adjustable, see Table M.4 — Values of Rmod and R2
R3	5 kΩ
Rmod	Adjustable, see Table M.4 — Values of Rmod and R2
C1	10 pF
C2	5 – 30 pF
C3	100 pF
C4	470 pF
D1, D2, D3, D4	Recommended: BAR43
Dz	Recommended: BZX84-C14 / T1, 300 mW, SMD 15 V
N1	N-MOS FET, 10 pF max. Output capacitance to ground. Recommended: BSS83

For X=30 and *H* = 2 A/m (rms) the load modulation amplitude ($X/H^{1,2}$) is 13,1 mV.

Adjustment of the R2 and Rmod values should be done in the test PCD assembly.

Adjustment of the Reference PICC load modulation amplitude level for V_{DC} = 6 V at field strength values from 2 A/m (rms) up to 6 A/m (rms) result in the following nominal modulation resistor values.

Table M.4 — Values of Rmod and R2

Load Modulation Amplitude mV	Freq MHz	*H* A/m (rms)	R2 Ω	Rmod kΩ
13,1	15	2	705	1,118
13,1	15	2,5	525	1,047
13,1	15	3	437	0,966
13,1	15	3,5	370	0,898
13,1	15	4	320	0,845
13,1	15	4,5	285	0,800
13,1	15	5	255	0,765
13,1	15	5,5	230	0,745
13,1	15	6	210	0,732
13,1	18	2	5100	4,670
13,1	18	2,5	703	1,376
13,1	18	3	510	1,045
13,1	18	3,5	380	0,941
13,1	18	4	320	0,880
13,1	18	4,5	285	0,825
13,1	18	5	255	0,785
13,1	18	5,5	230	0,760
13,1	18	6	210	0,740

NOTE 1 These resistor values are nominal values and should be used as a guideline when adjusting R2 and Rmod.

NOTE 2 V_{DC} should be measured using Reference PICC when no 847 KHz switching signal is applied to the probe.

M.3.7 Test report

The test report should include the number of passed tests versus the total number of tests. A description of each test, the information if the test was pass or fail, the number of different samples and the date of the tests should be included.

M.4 Layer 2 tests

M.4.1 Operating field strength test (Types A and B)

M.4.1.1 Purpose

The purpose of this test is to check if the PCD meets the energy performance requirements according to [5] (clause 6.2) and clause 8.1. To include a margin of 0,5 A/m (rms) to the ISO limits, the field strength under loaded conditions should be between 2,0 A/m (rms) (1,5 + 0,5) and 7,0 A/m (rms) (7,5 - 0,5) at all measurement positions defined in clause M.3.5.

M.4.1.2 Test procedure

As a measurement device, the Reference PICC for field and power measurements defined in M.3.6 should be used. The test should be performed at -10 °C, RT and 50 °C (see restriction in section M.3.4 Nominal values) on one sample at bit rate of *fc*/128.

Additionally, the value of V_{DC} should be recorded for all positions. These values are required for the load amplitude modulation test in clause M.4.2 Load modulation reception test (Type A and B).

For H_{min} perform the following steps:

a) Adjust the resonance frequency of the Reference PICC to 15 MHz as described in clause 8.1.2.

b) Put the Reference PICC into the test PCD assembly.

c) Adjust the resistor R2 to get a V_{DC} of 6 V at field strength of 2 A/m (rms).

d) At any measurement position defined in clause M.3.5 the V_{DC} should be greater or equal to 6 V.

For H_{max} perform the following steps:

a) Adjust the resonance frequency of the Reference PICC to 18 MHz as described in clause 8.1.2.

b) Put the Reference PICC into the test PCD assembly.

c) Adjust the resistor R2 to get a V_{DC} of 6 V at field strength of 7 A/m (rms).

d) At any measurement position defined in clause M.3.5 the V_{DC} should be less or equal to 6 V.

NOTE 1 This test includes field strength and power measurements, clauses 8.1 and 8.2.

NOTE 2 H_{min} and H_{max} values are defined to keep a margin to the field strength range for the PICC test.

NOTE 3 Additional tests may be performed using a Reference PICC resonance frequency of 13,56 MHz for H_{min} and 19 MHz for H_{max}.

M.4.1.3 Test report

The test report should include the number of passed tests versus the total number of tests, a test description, and the number of different samples and the date of the tests.

M.4.2 Load modulation reception test (Type A and B)

An ISO Reference PICC for load modulation tests does not give the possibility to test the load modulation amplitude with each PCD. In order to adapt this test, the load-switching signal should be a response to a request command and should be synchronous to a request command as defined in ISO/IEC 10373-6:2001/AM2:2006

M.4.2.1 Purpose

The purpose of this test is to determine if the PCD is able to receive and demodulate signals with minimum load modulation amplitude. The PCD should provide a trigger signal (e.g. pulse at beginning or end of PCD command) to the load switching signal source (e.g. an arbitrary waveform generator) to send the response with required timings. The Reference PICC defined in clause M.3.6 should be used.

M.4.2.2 Test procedure

For minimum one sample and for each measurement position (as defined in clause M.7) and resonance frequency perform the following steps:

a) Adjust the resonance frequency of the Reference PICC to 15 MHz as described in ISO/IEC 10373-6:2001/AM2:2006, clause 8.1.2.

b) Put the Reference PICC into the Test PCD assembly (ISO/IEC 10373-6:2001/AM2:2006).

c) Adjust the resistor R2 to get a V_{DC} of 6 V at *H* = 2 A/m (rms) field strength according to ISO/IEC 10373-6:2001/AM4:2006.

d) Adjust the resistor Rmod to get the required load modulation amplitude of 13,1 mV (for nominal resistor values see Table in clause M.3.6)

e) Put the Reference PICC to the measurement position defined in clause M.3.5.

f) Adjust the distance along z axis between the Reference PICC and PCD until V_{DC} reaches 6 V.

g) Check if the PCD is able to receive and demodulate a valid response with required bit rate (see Table M.5 — Communication sequences).

h) Repeat steps b) to g) where the field strength should be increased in 0,5 A/m (rms) steps up to Hmax

i) Repeat steps a) to h) at Reference PICC resonance frequency of 18 MHz.

Table M.5 — Communication sequences

Bit rate	PCD command	PICC response
fc/128	REQ	ATQ coding & framing according to higher bit rate spec.
fc/64	REQ	ATQ coding & framing according to higher bit rate spec.
fc/32	REQ	ATQ coding & framing according to higher bit rate spec.
fc/16	REQ	ATQ coding & framing according to higher bit rate spec.

Table M.6 — Environment parameters

Parameter	Value
Measurement position	as defined in clause M.7
Bit rate	*fc*/128, *fc*/64, *fc*/32, *fc*/16
Temperature	-10 °C, RT, 50 °C (see restriction in clause M.3.4 "Nominal Values")
Reference PICC resonance frequency	15 MHz, 18 MHz
Load modulation amplitude	$LMA_{min} = 30/H^{1,2}$ mVpeak

M.4.2.3 Test report

The test report should include the number of passed tests versus the total number of tests, a test description, and the number of different samples and the date of the tests.

NOTE For bit rates higher than *fc*/128, the 'Transmit Pattern and Receive 14443' command as specified in Annex M.9.3.2 may be executed by the PCD.

M.4.3 Modulation index and waveform test

Digital amplitude demodulation should be used for calculating the envelope of the modulated carrier amplitude, e.g. Hilbert transformation. For an example program of the Hilbert transformation, see Annex N.

M.4.3.1 Type A

This test should verify if the modulated field of the PCD is complying with the described waveform explained in [5] (clause 8.1) and [8] (8.1). The parameters are rise and fall times, modulation index, and overshoots

Modification done according:

— Reference: ISO/IEC 10373-6:2001/AM4:2006 (Annex I), Reference PICC for modulation index and waveform test

— Reference: ISO/IEC 14443-2:2001 (clause 8.1, 9.1)

— Reference: ISO/IEC 14443-2:2001/AM1:2005 (clause 8.1, 9.1)

Test conditions for *fc*/128 are shown in ISO/IEC 14443-2:2001 (clause 8.1.2), the test conditions for *fc*/64, *fc*/32, *fc*/16 in ISO/IEC 14443-2:2001/AM1:2005 (clause 8.1.2).

M.4.3.1.1 Purpose

The purpose of this test is to determine the compliance of the PCD regarding waveform shapes. The test should show if the shapes of the modulated field is within the defined limits. The test should be performed according to ISO/IEC 10373-6:2001 (clause 8.3). The Reference PICC for modulation index and waveform test ISO/IEC 10373-6:2001/AM4:2006 (Annex I) should be used in addition to the calibration coil. A command with the required bit rate shall be sent by the PCD.

Adjust the resonance frequency of the Reference PICC to 16,5 MHz as described in ISO/IEC 10373-6:2001/AM2:2006 (clause 8.1.2).

M.4.3.1.2 Test procedure

For minimum one sample and for each measurement position (as defined in clause M.7) perform the following steps:

a) Put the Reference PICC into position defined in clause M.7.

b) Adjust the resistor R2 to get a V_{DC} of 6 V at current position.

c) Check if the waveform shapes are within the specified limits for all bit rates at current position.

Table M.7 — Specific environment parameters

Parameter	Value
Measurement position	as defined in clause M.7
Bit rate	*fc*/128, *fc*/64, *fc*/32, *fc*/16
Temperature	-10 °C, RT, 50 °C (see restriction in clause M.3.4 "Nominal Values")
Reference PICC resonance frequency	16,5 MHz

M.4.3.1.3 Test report

The test report should include the number of passed tests versus the total number of tests, a test description, and the number of different samples and the date of the tests.

NOTE 1 For better interoperability, a Reference e-Passport resonance frequency of 15 MHz should be used.

NOTE 2 For each bit rate, the corresponding table should be taken in account.

NOTE 3 For bit rates higher than *fc*/128, the ISO/IEC 14443-2 test command as specified in Annex M.9.3.1 may be executed with the PCD.

M.4.3.2 Type B

This test should check if PCD meets the requirements concerning waveform shapes, i.e. rise and fall times, modulation index, and overshoots.

M.4.3.2.1 Purpose

The purpose of this test is to determine the compliance of the PCD regarding waveform shapes (see table below). The test should show if the shapes of the modulated field is within the defined limits. The test should be performed according to ISO/IEC 10373-6:2001 (clause 8.3). The Reference PICC for modulation index and waveform test ISO/IEC 10373-6:2001/AM4:2006 (Annex I) should be used in addition to the calibration coil. A command with the required bit rate shall be sent by the PCD.

a) Adjust the resonance frequency of the Reference PICC to 16,5 MHz as described in ISO/IEC 10373-6:2001/AM2:2006 (clause 8.1.2).

M.4.3.2.2 Test procedure

For minimum one sample and for each measurement position (as defined in clause M.7) perform the following steps:

a) Put the Reference PICC into position defined in clause M.7.

b) Adjust the resistor R2 to get a V_{DC} of 6 V at current position.

c) Check at that position if the waveform shapes are within the specified limits for all bit rates, as defined in table below.

The ISO/IEC 14443-2 test command as specified in Annex M.9.3.1 may be executed with the PCD.

Table M.8 — Waveform shape requirements

Parameter	min	max
m = (a-b)/(a+b)	10 %	14 %
t_r, t_f	0 µs	0,8 µs
h_r, h_f	0	0,1 (a-b)

Table M.9 — Specific environment parameters

Parameter	Value
Measurement position	as defined in clause M.7
Bit rate	*fc*/128, *fc*/64, *fc*/32, *fc*/16
Temperature	-10 °C, RT, 50 °C (see restriction in clause M.3.4 "Nominal Values")
Reference PICC resonance frequency	16,5 MHz

M.4.3.2.3 Test report

The test report should include the number of passed tests versus the total number of tests, a test description, and the number of different samples and the date of the tests

NOTE 1 For better interoperability a Reference PICC resonance frequency of 15 MHz should be used.

NOTE 2 For bit rates higher than *fc*/128, the ISO/IEC 14443-2 test command as specified in Annex M.9.3.1 may be executed with the PCD.

NOTE 3 The higher bit rate requirements of 0,8 µs are sufficient for all bit rates defined here because the higher bit rate of 424 kbps is mandatory for the PICC.

M.5 Layer 3 timing and framing tests

All tests should be performed with one specific field strength between 2 A/m (rms) and 7 A/m (rms) within the operating volume of the PCD if not further specified.

All tests should be performed at RT if not further specified.

M.5.1 Frame delay time (Type A only)

M.5.1.1 Frame delay time PICC to PCD

M.5.1.1.1 Purpose

This test should check if the PCD can handle a FDT according to ISO/IEC 14443-3:2001. For this test, the same setup should be used as for the load modulation reception test.

Modification done according to:

— Reference: ISO/IEC 14443-3:2001 (clause 6.1.3), Frame delay time PICC to PCD

M.5.1.1.2 Test procedure

This test should check if a PCD command after a PICC response is not sent before a minimum frame delay time of 1172/*fc* after the PICC has sent ATQ. After ATQ the PCD should send an AC frame.

Table M.10 — Specific environment parameters

Parameter	Value
Bit rate	*fc*/128

M.5.1.1.3 Test report

The test report should include the number of passed tests versus the total number of tests, a test description, and the number of different samples and the date of the tests.

NOTE If possible, this test should be done for all commands, even during the protocol test.

M.5.1.2 Frame delay time PCD to PICC

M.5.1.2.1 Purpose

This test should check if the PCD can handle a FDT according to ISO/IEC 14443-3:2001. For this test, the same setup should be used as for the load modulation reception test.

Modification done according to:

— Reference: ISO/IEC 14443-3:2001 (clause 6.1.2), Frame delay time PCD to PICC

M.5.1.2.2 Test procedure

This test should check if the PCD is able to receive a PICC response within the FDT limits.

Table M.11 —FDT limits

Last Bit	Min FDT	Max FDT
0	1172/*fc*	1172/*fc* + 0,4 µs
1	1236/*fc*	1236/*fc* + 0,4 µs

Table M.12 — Specific environment parameters

Parameter	Value
Bit rate	*fc*/128

M.5.1.2.3 Test report

The test report should include the number of passed tests versus the total number of tests, a test description, and the number of different samples and the date of the tests.

NOTE 1 The test should be done for a REQA/WUPA command and should be carried out with other commands, too (see ISO/IEC 14443-3:2001/AM1:2005).

NOTE 2 In order to improve interoperability, the following values should be used (ISO limits ± 1 carrier period):.

Table M.13 — Parameters for improved interoperability

Last Bit	Min FDT	Max FDT
0	1172/*fc* – 1/*fc*	1172/*fc* + 0,4 µs + 1/*fc*
1	1236/*fc* – 1/*fc*	1236/*fc* + 0,4 µs + 1/*fc*

M.5.2 Request guard time (Type A only)

This test should check if the PCD can handle multiple REQA commands according to ISO/IEC 14443-3:2001. For this test, the same setup should be used as for the load modulation amplitude test.

Modification done according:

— Reference: ISO/IEC 14443-3:2001 (clause 6.1.4), Request Guard Time

M.5.2.1.1 Purpose

The purpose of this test is to determine the Request Guard Time of two consecutive REQA/WUPA commands.

Table M.14 — Specific environment parameters

Parameter	Value
Bit rate	*fc*/128

M.5.2.2 Test report

The test report should include the number of passed tests versus the total number of tests, a test description, and the number of different samples and the date of the tests.

NOTE This test is only relevant for PCD's, which send consecutive REQA/WUPA.

M.5.3 Bit boundaries (Type B only)

M.5.3.1 Purpose

The purpose of this test is to check whether the PCD meets the bit boundary requirements according to ISO/IEC 14443-3:2001/AM1:2005 (7.1.1).

Table M.15 — Specific environment parameters

Parameter	Value
Bit rate	*fc*/128, *fc*/64, *fc*/32, *fc*/16

M.5.3.2 Test report

The test report should include the number of passed tests versus the total number of tests, a test description, and the number of different samples and the date of the tests

M.5.4 Start-of-Frame & End-of-Frame-Timing (SOF & EOF) (Type B only)

M.5.4.1 Purpose

The purpose of this test is to check whether the PCD meets SOF & EOF requirements according to ISO/IEC 14443-3:2001 (clause 7.1.4 and 7.1.5).

Table M.16 — Specific environment parameters

Parameter	Value
Bit rate	*fc*/128, *fc*/64, *fc*/32, *fc*/16

M.5.4.2 Test report

The test report should include the number of passed tests versus the total number of tests, a test description, and the number of different samples and the date of the tests.

M.5.5 Extra guard time (EGT) (Type B only)

M.5.5.1 Purpose

The purpose of this test is to check whether the PCD meets the EGT requirements according to ISO/IEC 14443-3:2001/AM1:2005 (7.1.2).

Table M.17 — EGT limits

	min	max
EGT	1 etu	6 etu

Table M.18 — Specific environment parameters

Parameter	Value
Bit rate	*fc*/128, *fc*/64, *fc*/32, *fc*/16

M.5.5.2 Test report

The test report should include the number of passed tests versus the total number of tests, a test description, and the number of different samples and the date of the tests.

M.5.6 Timing before PICC Start-of-Frame (TR0 & TR1) (Type B only)

M.5.6.1 Purpose

The purpose of this test is to check whether the PCD meets the TR0 and TR1 requirements according to ISO/IEC 14443-3:2001 (clause 7.1.6).

Table M.19 — TR0 & TR1 limits

	min	max
TR0	64/fs	256/fs
TR1	80/fs	200/fs

Table L.20 — Specific environment parameters

Parameter	Value
Bit rate	*fc*/128, *fc*/64, *fc*/32, *fc*/16

M.5.6.2 Test report

The test report should include the number of passed tests versus the total number of tests, a test description, and the number of different samples and the date of the tests.

NOTE In order to improve interoperability, the following values should be used:

Table M.21 — TR0 & TR1 limits for improved interoperability

	min	max
TR0	60/fs	260/fs
TR1	76/fs	204/fs

M.5.7 Timing before PCD Start-of-Frame (TR2) (Type B only)

M.5.7.1 Purpose

The purpose of this test is to check whether the PCD meets the minimum TR2 requirements. TR2 limits are tested according to the [11].

Table M.22 — TR2 limits

b3	b2	minimum TR2	maximum TR2
0	0	10 etu +32/fs	n/a
0	1	10 etu+128/fs	n/a
1	0	10 etu+256/fs	n/a
1	1	10 etu+512/fs	n/a

The bits b2 and b3 are negotiated in the PICC ATQB 'Protocol Type' half byte.

Table M.23 — Specific environment parameters

Parameter	Value
Bit rate	*fc*/128, *fc*/64, *fc*/32, *fc*/16

M.5.7.2 Test report

The test report should include the number of passed tests versus the total number of tests, a test description, and the number of different samples and the date of the tests.

M.6 Layer 3 and layer 4 protocol tests

These tests provide a basic set of tests to be performed to check compliance to ISO/IEC 14443 protocol layers. All tests are based on and should be evaluated according to the current standard.

For all test cases, make sure that the physical and electrical tests as mentioned in the clauses above have passed.

Test procedure:

Setup as defined for the electrical tests should be used and is afterwards called ″test apparatus″. All tests should be performed with one specific field strength between 2 A/m (rms) and 7 A/m (rms) within the operating volume of the PCD if not further specified.

All tests should be performed at RT if not further specified.

The test apparatus should be able to emulate the protocol, to measure, monitor the timing of the logical Input/Receive line relative to the CLK frequency, and be able to analyze the I/O-bit stream in accordance with the protocol.

The tests are based on the ISO/IEC 10373-6:2001/Amd 3:2006 specification. For the test commands typical commands should be used. This could be for example for TEST_COMMAND1 the READ BINARY command. Other commands specified dependent on their expected behavior might also be used. The command used may differ between different products and should be documented in the report.

The functionality as described in M.3.1 ″Test setup″ should be used either with the final operating system (preferred way) or with dedicated test commands.

M.6.1 Type A activation

These tests should ensure the start-up and the activation is according to ISO/IEC 14443-3:2001 clause 6. These tests are split up to collision handling, the handling of RATS and PPS, and the handling of CID during activation.

M.6.1.1 Handling of collisions

M.6.1.1.1 Purpose

The purpose of this test is to check the correct behavior on collisions as defined in ISO/IEC 14443-3:2001. The tests specified in the sub-clause ″Handling of bit collision during ATQA″ (clause H.2.3) and ″Handling of anticollision loop″ (clause H.2.4) of /IEC 10373-6:2001/AM3:2006 should be used. The detailed test procedure is not specified herein.

M.6.1.1.2 Test report

The test report should state whether the response was according to ISO/IEC 14443-3:2001 respectively to ISO/IEC 10373-6:2001/AM3:2006 or not. Additionally possible proprietary paths of the ″Select sequence flow chart″ specified in ISO/IEC 14443-3:2001 (clause 6.4.1) should not negatively affect the report. The report should include the number of samples tested and the date.

M.6.1.2 Handling of RATS (including frame size selection)

M.6.1.2.1 Purpose

The purpose of this test is to check the correct behavior of RATS and the handling of ATS as defined in ISO/IEC 14443-4:2001 (clause 5.6.1.1). The tests specified in the sub-clause ″Handling of RATS and ATS″ (clause H.2.5) and ″Frame size selection mechanism″ (clause H.2.7) of ISO/IEC 10373-6:2001/AM3:2006 should be used. The detailed test procedure is not specified herein.

M.6.1.2.2 Test report

The test report should state whether the response was according to ISO/IEC 14443-4:2001 respectively to ISO/IEC 10373-6:2001/AM3:2006 or not. The report should include the number of samples tested and the date.

M.6.1.3 Handling of PPS

M.6.1.3.1 Purpose

The purpose of this test is to check the correct behavior on handling a PPS response as defined in ISO/IEC 14443-4:2001 (clause 5.6.2.1). The tests specified in the sub-clause ″Handling of PPS response″ (clause H.2.6) of ISO/IEC 10373-6:2001/AM3:2006 should be used. The detailed test procedure is not specified herein.

M.6.1.3.2 Test report

The test report should state whether the response was according to ISO/IEC 14443-4:2001 respectively to ISO/IEC 10373-6:2001/AM3:2006 or not. The report should include the number of samples tested and the date.

M.6.1.4 Handling of CID during activation

M.6.1.4.1 Purpose

The purpose of this test is to check the correct behavior on handling CID during activation as defined in ISO/IEC 14443-4:2001 (clause 5.6.3). The tests specified in the sub-clause ″Handling of the CID during activation by PCD″ ISO/IEC 10373-6:2001/AM3:2006 (clause H.2.9) of should be used. The detailed test procedure is not specified herein.

M.6.1.4.2 Test report

The test report should state whether the response was according to [7] respectively to ISO/IEC 10373-6:2001/AM3:2006 or not. The report should include the number of samples tested and the date.

M.6.2 Type B activation

M.6.2.1 Frame size selection

M.6.2.1.1 Purpose

The purpose of this test is to check the correct behavior of the frame size selection mechanism as defined in ISO/IEC 14443-3:2001 (clause 7.9). The tests specified in the sub-clause ″Frame Size Selection Mechanism″ (clause H.3.2) of ISO/IEC 10373-6:2001/AM3:2006 should be used.

M.6.2.1.2 Test report

The test report should state whether the response was according to the scenario defined in ISO/IEC 10373-6:2001/AM3:2006 (clause H.3.2). The report should include the number of samples tested and the date.

M.6.2.2 Bit rate selection

M.6.2.2.1 Purpose

The purpose of this test is to check the correct behavior of the bit rate selection mechanism as defined in ISO/IEC 14443-3:2001/AM1:2005. The tests specified in ISO/IEC 10373-6:2001/AM5:2006 (Annex K) should be used.

M.6.2.2.2 Test report

The test report should state whether the behavior was according to ISO/IEC 14443-3:2001/AM1:2005 respectively ISO/IEC 10373-6:2001/AM3:2006. The report should include the number of samples tested and the date.

M.6.2.3 Handling of CID during activation

M.6.2.3.1 Purpose

The purpose of this test is to check the correct behavior on handling CID during activation as defined in [7]. The tests specified in the sub-clause ″Handling of the CID during activation by the PCD″ (clause H.3.3) of ISO/IEC 10373-6:2001/AM3:2006 should be used.

M.6.2.3.2 Test report

The test report should state whether the response was according to [7] respectively to ISO/IEC 10373-6:2001/AM3:2006 or not. The report should include the number of samples tested and the date.

M.6.3 Handling of the polling loop (Type A and B)

M.6.3.1.1 Purpose

The purpose of this test is to check the correct behavior during polling for Type A and Type B PICC's as defined in ISO/IEC 14443-3:2001 (clause 5). The test specified in the sub-clause ″Handling of the polling loop″ of ISO/IEC 10373-6:2001/AM3:2006 (clause H.4.1) should be used. The detailed test procedure is not specified herein.

M.6.3.1.2 Test report

The test report should state whether the response was according to ISO/IEC 14443-3:2001 respectively to ISO/IEC 10373-6:2001/AM3:2006 or not. The report should include the command set used for testing.

M.6.4 Data exchange protocol tests (Type A and B)

Data exchange protocol tests should ensure the logical operation of the PCD is according to ISO/IEC 14443-4:2001. These tests are valid for both, Type A, Type B whereas the activation before running these tests is different, and listed below. All tests are based on the currently available standards.

The activation for Type A should be done according to the ISO/IEC 10373-6:2001/AM3:2006 H.1.8.2 ″Activation procedure for Type A protocol test methods″.

The activation for Type B should be done according to the ISO/IEC 10373-6:2001/AM3:2006 H.1.8.3 ″Activation procedure for Type B protocol test methods″.

M.6.4.1 Error detection and recovery

The purpose of this test is to determine the behavior of PCD when a transmission error occurs according to ISO/IEC 14443-4:2001, 7.5.5. These tests specified in ISO/IEC 10373-6:2001/AM3:2006 cover standard communication blocks, blocks where the PCD uses chaining and blocks where the PICC uses chaining.

The PICC chaining tests could be performed without knowing dedicated command behavior on IUT. Any command could be divided into two parts e.g. the response to a READ BINARY could be sent in two chained packets.

The IUT chaining is harder to achieve. If the higher layer functionality is not known in detail or a chaining command is not used in the application these tests could not be performed. Therefore, it is optional.

M.6.4.1.1 Purpose

The purpose of this test is to determine the behavior of PCD when a transmission error occurs according to ISO/IEC 14443-4:2001, 7.5.5. These tests specified in ISO/IEC 10373-6:2001/AM3:2006 cover standard communication blocks, blocks where the PCD uses chaining and blocks where the PICC uses chaining. The detailed test procedure is not specified herein.

M.6.4.1.2 Test report

The test report should state whether the response was according to ISO/IEC 14443-4:2001 respectively to ISO/IEC 10373-6:2001/AM3:2006. The report should include the command set used for testing.

M.6.4.2 Request for waiting time extension

M.6.4.2.1 Purpose

The purpose of this test is to determine the behavior of the PCD when the PICC use a request for a waiting time extension (see ISO/IEC 14443-4:2001, 7.3). The mechanism of maintenance of WTX by the PCD is tested too. These tests specified in ISO/IEC 10373-6:2001/AM3:2006 H.4.2 ″Reaction of the PCD to request for waiting time extension″. The detailed test procedure is not specified herein.

M.6.4.2.2 Test report

The test report should state whether the response was according to ISO/IEC 10373-6:2001/AM3:2006 H.4.2 ″Reaction of the PCD to request for waiting time extension″. The report should include the command set used for testing.

M.7 Measurement points

Table M.24 —PICC Application specific measurement points

PCD design type		Volume definition			Measurement points	
		X dimension	Y dimension	Z dimension mm	X-Y-plane	Height mm
1	Single step PCDs[a]	Twice ID3 + 20 % (of ID3) for the size of an open passport booklet (ID3) enlarged by 10 %	Size of a passport booklet (ID3) enlarged by 10 %	7,5	All four corners of both connected ID 3 + 10 % fields, additionally in the center of both fields	$Z_0 = 0$ $Z_1 = 7,5$ Z_{max} as specified by manufacturer (if $Z_{max} > 7,5$)
1a	Similar to PCD design type 1, but the two parts of the volume are arranged angularly, not in-line					
2	Full page PCDs[b]	ID3 + 10 % for the size of a passport booklet (ID3) enlarged by 10 %	Size of a passport booklet (ID3) enlarged by 10 %	7,5	All four corners of the ID 3 + 10 % field, additionally in the center of the field	$Z_0 = 0$ $Z_1 = 7,5$ Z_{max} as specified by manufacturer (if $Z_{max} > 7,5$)
99	Other PCDs	ID3 +10 % for the size of a passport booklet (ID3) enlarged by 10 %	Size of a passport booklet (ID3) enlarged by 10 %	20	All four corners of the ID 3 + 10 % field, additionally in the center of the field	$Z_0 = 0$ $Z_1 = 7,5$ $Z_{max} = 20$ or as specified by manufacturer (if $Z_{max} > 20$)

[a] Document PCDs that are able to read the entire data page of an opened passport and that are able to read the data from the PICC without any replacement of the passport on the PCD, independently from the location of the chip inside the passport document (i.e., front cover, back cover, data page, middle page)

[b] Document PCDs that are able to read the entire data page of an opened passport as well as the data contained in the PICC. A replacement of the passport may be required.

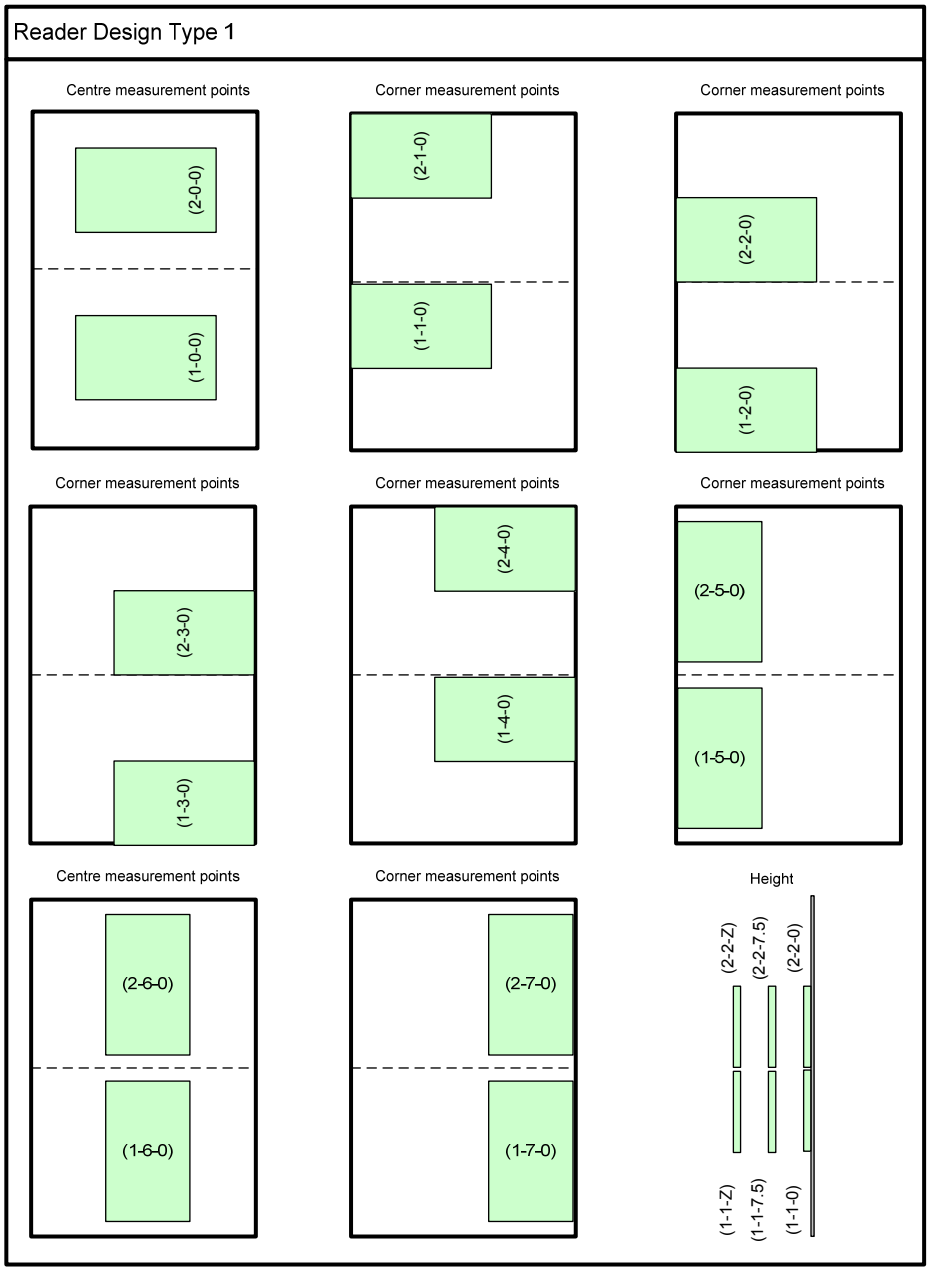

Figure M.2 — Measurement points PICC PCD design type 1

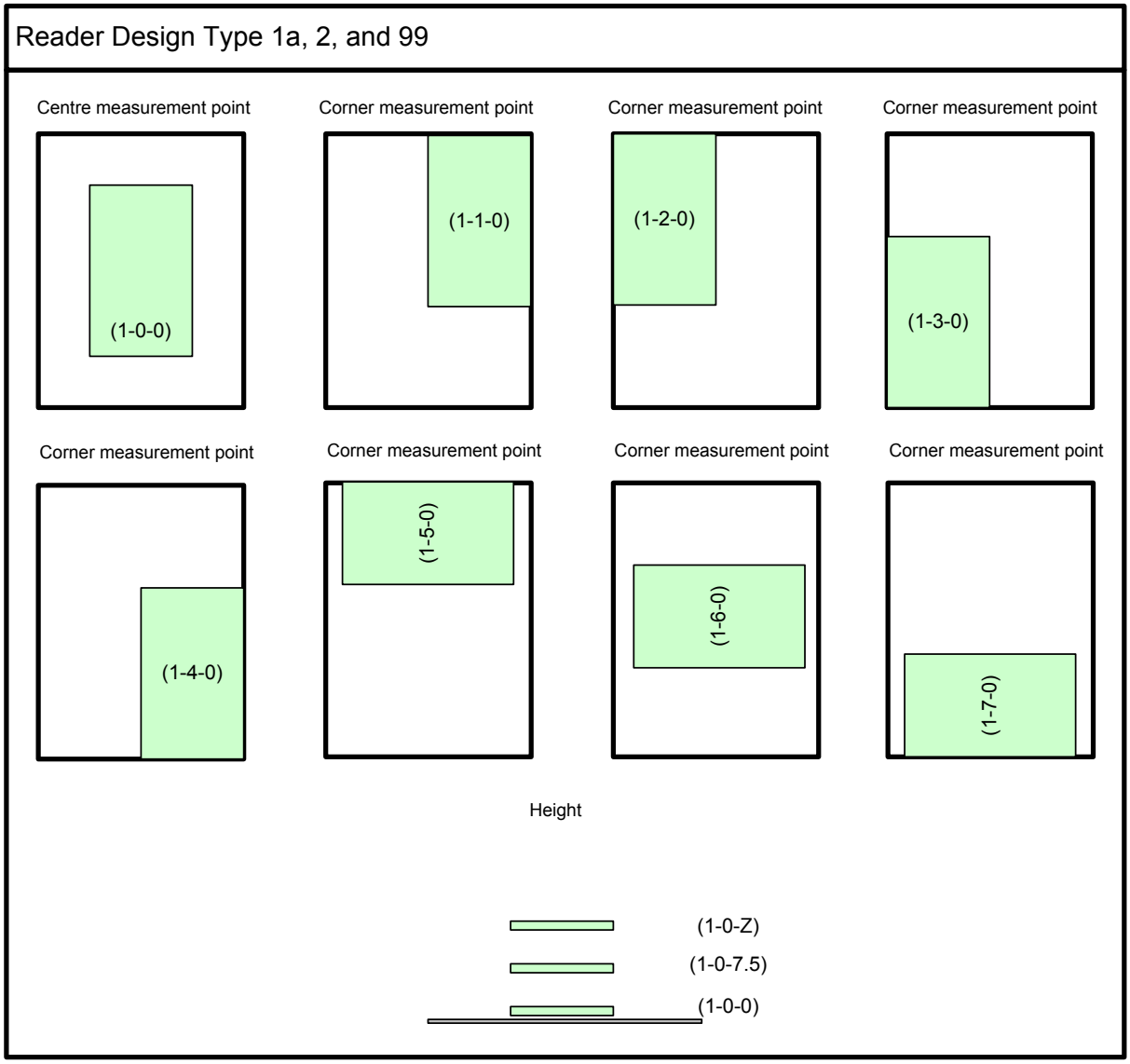

Figure M.3 Measurement points PICC PCD design type 1a, 2, and 99

M.8 Comparison PCD – PICC test

Table M.25 — Comparison PCD – PICC Test

ISO Layer	Test description	PICC	PCD
1	Coil Dimension Check	Conditional	No
	Static Electricity (ESD) Tests	Yes	No
	X-Ray Tests	No	No
	UV Tests	No	No
	H_{max} (12 A/m (rms)) Test	Yes	No
2	Load modulation amplitude	Check if the load modulation amplitude is higher than the limit	Check if the PCD is able to handle the whole load modulation amplitude range
	Operating field strength	Check the whole range from 1,5 – 7,5 A/m (rms)	Check if the available power of the PCD is in-between 1,5and 7,5 A/m (rms)
	Communication stability	Check the whole range of valid signal shapes, (modulation index, rising- and falling edges, overshoot and timings)	Check if the shape of the modulated field is in-between the valid limits (modulation index, rising- and falling edges, overshoot and timings)
	Threshold resonance frequency	Optional	No
3	Frame Delay Time (Type A)	Check if the response starts after the right time.	Check the whole range, ±200 ns
	Bit Boundaries (Type B)	No	Check if the bit boundaries are within the valid limits.
	Start-of-Frame & End-of-Frame Timings (SOF & EOF) (Type B)	Check if the SOF and EOF timings are within the valid limits.	Check if the SOF and EOF timings are within the valid limits.
	Extra Guard Time (EGT) (Type B)	Check if the EGT timing is within the valid limits.	Check if the EGT timing is within the valid limits.
	Timing Before PICC Start of Frame (TR0 & TR1) (Type B)	Check if the TR0 & TR1 timings are within the valid limits.	Check if the TR0 & TR1 timings are within the valid limits.
	Timing Before PCD Start of Frame (TR2) (Type B)	Check if the TR2 timing is within the valid limits.	Check if the TR2 timing is within the valid limits.

M.9 Interface definition of TM-PDUs

M.9.1 Scope

This clause specifies a test management protocol according to ISO/IEC 10373-6:2001 to be applied to an PCD during conformity evaluations. The test commands, called test management protocol data units (TM-DPU), follow the architecture described in the PC/SC Part 3: Requirements for PC-Connected Interface Devices, Revision 2.01.05.

These test commands are persistent in each certified PCD to perform tests in the field as well.

This PC/SC implementation is optional. Using the PC/SC framework, test houses can minimize their efforts to establish the evaluation environment. PCD providers can use universal test applications if there are any.

If a supplier provides a PC/SC implementation, it has to be compliant to the latest released version on the consortium website (http://www.pcscworkgroup.com/specifications/overview.php).

M.9.2 Command syntax and transportation

The structure of the TM-PDUs follows the byte sequential command structure for smart cards, so called APDUs (Application Protocol Data Unit) according to ISO/IEC 7618-4. The APDUs are distinguished by their direction, to or from the PCD:

— Command-APDU (C-APDU)

— Response-APDU (R-APDU)

For each C-APDU sent to the PCD by the test application, an R-APDU will be returned as a confirmation. R-APDUs will not be confirmed by the PCD.

M.9.2.1 Command APDU

C-APDUs are byte sequences consisting of two parts: Header and Body.

Table M.26 — Structure of a C-APDU

<table>
<tr><td colspan="7"><C-APDU></td></tr>
<tr><td colspan="7">Length: 4 ... ((0 … 3) + Lc + (0 … 3))</td></tr>
<tr><td colspan="4">Header
mandatory</td><td colspan="3">Body
[optional]</td></tr>
<tr><td colspan="4">Length: 4</td><td colspan="3">Length: 0 ... ((0 ... 3) + Lc + (0 ... 3))</td></tr>
<tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5 ... 7</td><td>((5 ... 7) + 1) ...
(Lc + ((5 ... 7) + 1))</td><td>(Lc + ((5 ... 7) + 2)) ...
(Lc + ((5 ... 7) + 2) + (1 ... 3))</td></tr>
<tr><td rowspan="2">CLA</td><td rowspan="2">INS</td><td rowspan="2">P1</td><td rowspan="2">P2</td><td>[Lc]</td><td rowspan="2">[Data Field
<Lc Bytes of Data>]</td><td>[Le]</td></tr>
<tr><td>Max. Value indicated by
Lc < = 65535</td><td>Max. Value indicated by
Le < = 65536</td></tr>
</table>

The header only (first four bytes) is mandatory. The body is optional and may contain data with prior length indicator and/or length indicator for expected R-APDU. The presence depends on the command and application case or context.

M.9.2.2 Response APDU

The response to a C-APDU will be returned in general as R-APDU. Optionally the R-APDU may contain data. The two status bytes SW1SW2 are mandatory.

Table M.27— Structure of the R-APDU

<R-APDU>		
Body [optional]	**Trailer mandatory**	
Requested Information	Status Word	
Length: 0 ... [<Le> of C-APDU]	Length: 2 Byte	
Position: 1 ... (1 + [<Le> of C-APDU])	Pos.: 1 ... (1 + [<Le> of C-APDU])	Pos.: 2 ... (2 + [<Le> of C-APDU])
[Information Field]	SW1	SW2

The trailer of the R-APDU transports the result of an operation. It has to be interpreted byte wise. SW1 classifies the result in general and SW2 gives an exact value for the indicated error class. The following classes are defined:

Table M.28 — Return Code Classes

Class (SW1)	Description
'90'	Normal Processing
'62', '63', '6C'	Warning
'64', '65'	Execution Error
'67' to '6F'	Checking Error

The value of SW2 is class specific.

M.9.2.3 Common return codes

Table M.29 —Common return codes

	SW1	SW2	Description
Success	'90'	'00'	Command successful
Warning	'6C'	'XX'	Le and available data are not same; 'XX' is the number of available data. If Le= 0x00, all available data is returned.
Error	'64'	'00'	Timeout, expecting response from card but no response within the time
	'64'	'01'	Internal error
	'67'	'00'	Wrong length
	'68'	'00'	Class byte is not correct
	'6A'	'81'	INS not supported
	'6A'	'82'	Function is not supported
	'6B'	'00'	Wrong parameter P1-P2

M.9.2.4 Command transportation

The commands can be transported via any interface. The applicant should enable the test house to issue the specified test commands.

The applicant may provide the test houses with PC/SC drivers. In this case, all commands will be transported using the SCARD_Transmit function.

A PCD (or its related driver) can distinct between PICC commands and PCD control commands via the class byte. The value 0xFF is reserved for other purposes and can never be used by an ISO compliant PICC. Therefore, the test commands can be sent on the same 'channel' as the PICC commands. In addition, there is no need for a special function call or address to indicate control commands.

Following this way, existing test equipment can be used to apply PCD test commands and real PICC commands in parallel for testing.

M.9.3 Commands for testing

The following commands may be used to test the PCD.

NOTE All RFU bits and bytes described here should be set to 0.

M.9.3.1 ISO/IEC 14443-2 test command

This command may be used to test the RF interface, the modulation index, framing and coding of the data, transmitted by the PCD. Testing with this command does not mandate the presence of an PICC but it may be inserted to the field in order to check the mutual induction to the magnetic field.

Table M.30 — C-APDU for ISO/IEC 14443-2 Test Command

Command	CLA	INS	P1	P2	Lc	Data in	Le
ISO/IEC 14443-2 Test	0xFF	0x92	xx	RFU	xx	xx	-

Table M.31 — R-APDU for ISO/IEC 14443-2 Test Command

Data out	SW1SW2
-	xxxx

Table M.32 — P1-Subcarrier and Data Coding Parameter

b7	b6	B5	b4	b3	b2	b1	b0	Description
0	0	------						No carrier, RF is turned off
0	1	------						No sub-carrier, just carrier, RF is turned on
1	0	------						Carrier modulated with sub-carrier, if there are some bytes to transmit, Lc = n, n≠ 0
1	1	------						RFU
-----		RFU	0	-------				ISO/IEC 14443 Type A transmission[a]
-----			1	-------				ISO/IEC 14443 Type B transmission[a]
-----				RFU		0	0	Transmission at 106 kbps
-----						0	1	Transmission at 212 kbps
-----						1	0	Transmission at 424 kbps
-----						1	1	Transmission at 848 kbps
[a] The transmission according to the normal frame, which includes all framing e.g. start bit, stop bit, parity bit, SOF, EOF, CRC etc.								

The following table lists the return codes in addition to the common return codes:

Table M.33 — Return Codes of ISO/IEC 14443-2 Test Command

SW1SW2	Meaning
'6A83'	Transmission type not supported
'6A84'	Transmission speed is not supported

M.9.3.2 Transmit pattern and receive ISO/IEC 14443 command

This command transmits a bit pattern independent from any PICC command structure and coding. The pattern can be used to measure modulation index, rise and fall times, overshoots etc. This command can be used to test by using a PICC to receive any pattern by the PICC.

Table M.34 — C-APDU for Transmit Pattern and Receive ISO/IEC 14443

Command	CLA	INS	P1	P2	Lc	Data in	Le
Tx Pattern	0xFF	0x94	xx	xx	xx	Pattern	xx

Table M.35 — R-APDU for Transmit Pattern and Receive ISO/IEC 14443

Data out	SW1SW2
-	xxxx

Table M.36 —P1 of Transmit Pattern and receive ISO/IEC 14443

b7	b6	b5	b4	b3	b2	b1	b0	Description
0	0	0	0	-	-	-	-	RFU
-	-	-	-	-	-	-	0	ISO/IEC 14443 Type A Transceive data coding
-	-	-	-	-	-	-	1	ISO/IEC 14443 Type B Transceive data coding
				xxx			-	No of bits of last byte will be transmitted, 0 means all bits will be transmitted

NOTE The data in the 'data in' field is not interrupted; the complete data is sent to the air. No framing, e.g. start bit, stop bit, CRC, SOF, EOF is not added.

Table M.37 — P2 of Transmit Pattern and Receive (bit rate) ISO/IEC 14443

b7	B6	b5	b4	b3	b2	b1	b0	Description
RFU		-	-	-	RFU	0	0	Transmit at 106 kbps
		-	-	-		0	1	Transmit at 212 kbps
		-	-	-		1	0	Transmit at 424 kbps
		-	-	-		1	1	Transmit at 848 kbps
		RFU	0	0	-	-	-	Receive at 106 kbps
			0	1				Receive at 212 kbps
			1	0				Receive at 424 kbps
			1	1				Receive at 848 kbps

Table M.38 —Return codes of Transmit Pattern and Receive ISO/IEC 14443

SW1SW2	Meaning
'6A83'	Transmission type not supported
'6A84'	Transmission speed is not supported
'6A87'	Different bit rate is not supported
'6A8A'	Modulation index is not supported

M.9.3.3 ISO/IEC 14443-3 test command

This command transmits a 14443-3 command and returns the data received from the PICC.

Table M.39 —C-APDU for ISO/IEC 14443-3 Test Command

Command	CLA	INS	P1	P2	L_C	Data in	Le
ISO/IEC 14443-3 Test	0xFF	0x96	xx	xx	xx	xx	xx

Table M.40 —R-APDU for ISO/IEC 14443-3:2001 Test Command

Data out	SW1SW2
Response of the card	xxxx

Table M.41 — P1: Command byte

b7	b6	b5	b4	b3	b2	b1	b0	Description
--			0	ISO/IEC 14443 Type A command				
				0	0	0	1	REQA
				0	0	1	0	WUPA
				0	0	1	1	HLTA
				0	1	0	0	PCD does complete part 3 Type A, returns UID+SAK
				1	Anti-collision is handled by user			
					0	0	1	ANTICOLLISION Sel_level 1
					0	1	0	ANTICOLLISION Sel_level 2
					0	1	1	ANTICOLLISION Sel_level 3
					1	0	0	SELECT (Data in field should be 70+ last 4-byte UID + BCC)
				Other values are RFU				
			1	ISO/IEC 14443B type command				
				0	0	0	1	REQB (P2 sets the number of slot)
				0	0	1	0	WUPB (P2 sets the number of slot)
				0	0	1	1	HLTB
				0	1	0	0	Slot-MARKER (slot number in P2)
				0	1	0	1	ATTRIB (P2 sets the communication speed)
	Xx		----					No of repetitions of the command
x	---		----					0 means set all other parameters to the default value which is not stated in P2. 1 means send all data given in 'Data in' field with the command, P2 has no significance.

Lc: Number of bytes has to be sent to the card within this command except the command itself.

Data in: The data byte has to be sent within the command.

Table M.42 —P2: Coding of Bit rate for ATTRIB command

b7	b6	b5	b4	b3	b2	b1	b0	Description
					RFU	0	0	PCD to PICC 106 Kbps
						0	1	PCD to PICC 212 Kbps
						1	0	PCD to PICC 424 Kbps
						1	1	PCD to PICC 848 Kbps
		RFU	0	0	--			PICC to PCD 106 Kbps
			0	1	--			PICC to PCD 212 Kbps
			1	0	--			PICC to PCD 424 Kbps
			1	1	--			PICC to PCD 848 Kbps
CID								Logical card identifier *

Only up to four cards are supported, for more cards, select option b7 of P1 =1.

Table M.43 —P2: Coding of Slot number of REQB/WUPB command

b7	b6	B5	b4	b3	b2	b1	b0	Description
RFU					xxx			Number of slot. N = $2^{(b2b1b0)}$; (b2b1b0 = 0 means N = 2^0 = 1)

Table M.44 —P2: Coding of slot number of Slot-MARKER command

b7	b6	b5	b4	b3	b2	b1	b0	Description
RFU				0	0	0	1	Slot number = 2
				0	0	1	0	Slot number = 3
				..	..	..	..	……..
				1	1	1	1	Slot number = 16

The return codes in addition to the common return codes are listed in the following table:

Table M.45 —Return codes of ISO/IEC 14443-3 Test Command

SW1SW2	Meaning
'6A85'	The command is not supported
'6A86'	The repetition is not allowed
'6A87'	Different bit rate is not supported
'6A88'	Requested buffer size is bigger than the PCD buffer size

M.9.3.4 ISO/IEC 14443-4 test command

This command transmits a ISO/IEC 14443-4 command and returns the data received from the PICC.

Table M.46 —C-APDU for ISO/IEC 14443-4 Test Command

Command	CLA	INS	P1	P2	Lc	Data in	Le
ISO/IEC 14443-4 Test	0xFF	0x98	xx	xx[a]	xx	xx	xx
[a] P2 is coded according to P1 or '00'							

Table M.47 —R-APDU for ISO/IEC 14443-4 Test Command

Data out	SW1SW2
Response of the card (see note below)	xxxx

NOTE If there is a card response SW1SW2, this is considered as the 'Response of the card' data, e.g. if a 'select file' command returns '6A82', here the complete R-APDU will be '6A829000', similarly if the card returns '9000', the complete R-APDU will be '90009000'.

Table M.48 —P1

b7	b6	b5	b4	b3	b2	b1	b0	Description
RFU						0	0	RATS (Type A only), P2 codes the parameter (FSDI and CID) according to ISO/IEC 14443-4
						0	1	PPS (Type A only), P2 codes the communication speed
						1	0	The complete data of 'Data in' field is transmitted to the card, user should add PCB and CID according to T=CL protocol.
						1	1	The complete data of 'Data in' field is transmitted to the card, PCD should take care of the PCB and CID, only I block is allowed in this mode.

P2 is coded according to P1 or '00'.

NOTE CRC is calculated by the PCD and appended to the end of the frame.

Table M.49 —P2 coded the communication speed for PPS command

b7	b6	b5	b4	b3	b2	b1	b0	Description
					RFU	0	0	PCD to PICC 106 Kbps
						0	1	PCD to PICC 212 Kbps
						1	0	PCD to PICC 424 Kbps
						1	1	PCD to PICC 848 Kbps
		RFU	0	0	--			PICC to PCD 106 Kbps
			0	1	--			PICC to PCD 212 Kbps
			1	0	--			PICC to PCD 424 Kbps
			1	1	--			PICC to PCD 848 Kbps
RFU								---

Table M.50 —P2 coded the Parameter byte of RATS command

b7	b6	b5	b4	b3	b2	b1	b0	Description
FSDI				CID				FSDI is according to the following table

Table M.51 —Coding of FSDI

FSDI	'0'	'1'	'2'	'3'	'4'	'5'	'6'	'7'	'8'	'9'-'F'
FSD	16	24	32	40	48	64	96	128	256	RFU

Table M.52 —Return codes of ISO/IEC 14443-4 Test Command

SW1SW2	Meaning
'6A87'	Different bit rate is not supported
'6A88'	Requested buffer size is bigger than the PCD buffer size

M.9.3.5 Miscellaneous command

This command can be used for proprietary purposes by the PCD vendor. A separated description has to be added by the vendor.

Table M.53 —Miscellaneous Command

Command	CLA	INS	P1	P2	Lc	Data in	Le
Miscellaneous	0xFF	0x9A	xx	xx	xx	xx	xx

As example to retrieve the PCD information, the command may be interpreted as follows:

Table M.54 —P1 structure of the Miscellaneous Command

b7	b6	b5	b4	b3	b2	b1	b0	Description
0	0	0	0	0	0	0	1	Returns PCD information as requested through P2
0	0	0	0	0	0	1	0	Generate trigger signal for ISO/IEC 14443 Type A[a]
0	0	0	0	0	0	1	1	Generate trigger signal for ISO/IEC 14443 Type B[a]
RFU								Other values are RFU
[a] PCD manufacturer will provide a description about the trigger signal and the port/pin to acquire it. P2 = '00'.								

Table M.55 —P2 structure of the Miscellaneous Command for P1 = '01'

b7	B6	b5	b4	b3	b2	b1	b0	Description
0	0	0	0	0	0	0	1	Returns vendor name
0	0	0	0	0	0	1	0	Returns vendor ID
0	0	0	0	0	0	1	1	Returns product name
0	0	0	0	0	1	0	0	Returns product ID
0	0	0	0	0	1	0	1	Returns product serial number
0	0	0	0	0	1	1	0	Returns product firmware version
0	0	0	0	0	1	1	1	Returns driver version
0	0	0	0	1	0	0	0	Returns PCD buffer size
0	0	0	0	1	0	0	1	Returns maximum bit rate supported by PCD
RFU								Other values are RFU

NOTE All return values are in ASCII string format.

Table M.56 —Return codes of the Miscellaneous Command

SW1SW2	Meaning
'6A89'	Information not available
'6A90'	Trigger signal is not supported

Annex N
(informative)

Hilbert transformation

N.1 Scope

This annex provides a source code for the Hilbert transform. It is informative for ePassport testing as well as other methods with equivalent results may be used.

N.2 Source code of Hilbert transformation programs

Example program for the evaluation of the waveform and modulation index.

The following programs written in C language extract the envelope of the modulated carrier using Hilbert transformation.

```
/ * * *                                                                    * * * /
/ * * * This program extract the envelope of modulated carrier             * * * /
/ * * * Input                                                              * * * /
/ * * * File in text format containing a table of two columns              * * * /
/ * * * (time and test PCD output voltage vd                               * * * /
/ * * *                                                                    * * * /
/ * * * Data format of input-file                                         * * * /
/ * * *                                                                    * * * /
/ * * * One data-point per line,                                          * * * /
/ * * *                                                                    * * * /
/ * * * {time[seconds], sense-coil-voltage[volts                          * * * /
/ * * *                                                                    * * * /
/ * * * Data-points shall be equidistant time                             * * * /
/ * * * Minimum sampling rate: 100 MSamples/second                        * * * /
/ * * * example for spreadsheet file (start in next line):               * * * /
/ * * * (time) , (voltage )                                              * * * /
/ * * * 3.00000e-06,1.00                                                 * * * /
/ * * * 3.00200e-06,1.01                                                 * * * /
/ * * *                                                                    * * * /
/ * * * Run:                                                             * * * /
/ * * * hilberttransformation Filename.                                  * * * /
/ * * * or                                                               * * * /
/ * * * hilberttransformation (default file name input.txt)              * * * /
/ * * *                                                                    * * * /
/ * * *                                                                    * * * /
/ * * * Description:                                                     * * * /
/ * * * HilbertTransformation.c--- Main program for extracting envelope  * * * /
/ * * * fftrm.c --- Code to perform fourier and inverse fourier          * * * /
/ * * * transformation                                                   * * * /
/ * * * fftrm.h --- Header file for fftrm.c                              * * * /
/ * * *                                                                    * * * /
```

```
/*****************************************************************************/
/*HilberTrnsformation.c                                                      */
/*Main program                                                               */
/*****************************************************************************/
```

```
# include <stdio.h>
# include <math.h>
# include <malloc.h>
#include <ctype.h>
#include <string.h>
```

```
# include "fftrm.h"

#define MAX_POINT 5000
#define M_PI 3.14159265358979323846264338327 95

int debug=0;
int fftdebug=0;

double *Gvalue;
double *Gtime;
double *Gr;
double *Gi;
double **G; /*Phase Changed*/
double *Gc;
doublecomplex *Gt_ifft;


/*File containing the input data*/

char *InputFileName ="input.txt" ;

/*This function reads the sampled data recorded in the file*/
int ReadData(void);
/*This function function performs the fourier transform*/
void Fft(void);
/*This function performs the necessary phase shift*/
void PhaseShifting(void);
/*This function performs the inverse fourier transfor*/
void Ifft(void);
/*Envelope reconstruction is done by this function*/
int EnvelopeReconstruction(void);

/*For fourier and inverse fourier transformation these two functions are used */
/*These functions are defined in fftrm.c */
int zffts ( int debug,doublecomplex *X,int M ); /*Defined in fftrm.c*/
int ziffts( int debug,doublecomplex *X,int M ); /*Defined in fftrm.c*/


int SampledPoints=0;
int N;
int row;
const int col=2;

int ReadData(void)
{
    float a,b;
    int i=0,num1;
    FILE *fp1;
    i=0;

    if ((fp1 = fopen(InputFileName,"r")) == NULL)
    {
        printf("Cannot open input file.\n");
        return 1;
    }


    printf("\nReading data from file ... ... ...%s\n",fp1);

    while(!feof(fp1))
    {

         fscanf(fp1,"%e,%e\n", &a, &b);

         Gtime[SampledPoints] = a;
         Gvalue[SampledPoints] = b;
         SampledPoints++;
         if (SampledPoints>= MAX_POINT) break;
```

```
    }

    fclose(fp1);

    fp1=fopen("inputfile.txt","w");
 if (!fp1)
    {
 fprintf(stdout,"Cann't write the sampled data in inputfile.txt. \n");

        return 1;

    }
 for(i=0; i<SampledPoints; i++)
 fprintf(fp1,"%e\n",Gvalue[i]); /*Gtime[i] has been omitted*/
 fclose(fp1);

    if(debug)
    {
    fp1=fopen("inputtime.txt","w");
 if (!fp1)
    {
 fprintf(stdout,"Cann't write the sampled data in inputtime.txt. \n");

        return 1;

    }
 for(i=0; i<SampledPoints; i++)
 fprintf(fp1,"%e\n",Gtime[i]); /*Gtime[i] has been omitted*/
 fclose(fp1);
    }

    if(debug)
    {
    if((fp1=fopen("inputfile.bin","wb"))!=NULL)   {
        num1=fwrite(Gvalue,sizeof(double),SampledPoints,fp1);
    fclose(fp1);
    }
    }

    if(SampledPoints<N)
    {
        for(i=SampledPoints;i<=N;i++)
        {
            Gvalue[i] = 0;
        }
    }

    fprintf(stdout,"\nInput file name = %s\n",InputFileName);
 fprintf(stdout,"Number of sampled data = %d\n",SampledPoints);
    return 0;

}/*End Of Function ReadData;*/

void Fft(void)
{
    doublecomplex *Gt_freq;

    FILE *fp1,*fp2,*fp3;
    int k,num1,num2,num3,z1;
```

```
    Gt_freq = (doublecomplex *)calloc(sizeof(doublecomplex),row);

    printf("\nPerforming FFT ... ... ...\n");

    /* FFT Procedure Starts for Sampled Data*/
    for(k=0;k<=N;k++){
        RE(Gt_freq[k])=Gvalue[k];
        IM(Gt_freq[k])=0.0;
    }

    if(debug){
        if((fp3=fopen("f.bin","wb"))!=NULL) {
        num3=fwrite(Gvalue,sizeof(double),row,fp3);
        fclose(fp3);
        }
    }

    z1=zffts(fftdebug,Gt_freq,row);/*FFT is done in spatial coordicate*/

    for (k=0;k<=N;k++) {
        Gr[k]=RE(Gt_freq[k]);
        Gi[k]=IM(Gt_freq[k]);
    }
 /* FFT Procedure Ends for Sampled Data*/

 /* Writing The Real And Imaginary Part Of Reflected Part for Debuging*/
 /* Writing the real part of sampled data*/

    if(debug) {
        if((fp1=fopen("Gr.bin","wb"))!=NULL){
            num1=fwrite(Gr,sizeof(double),row,fp1);
            fclose(fp1);
        }
        else
            fprintf(stdout,"Cann't Open Gr.bin");

        // Writing the img part of sampled data
        if((fp2=fopen("Gi.bin","wb"))!=NULL)  {
            num2=fwrite(Gi,sizeof(double),row,fp2);
            fclose(fp2);
        }
        else
            fprintf(stdout,"Cann't Open Gi.bin");
        fprintf(stdout,"Num of Real Part Data after FFT = %d\n",num1);
            fprintf(stdout,"Num of Img Part Data after FFT = %d\n",num2);
    }

 free(Gt_freq);

}/* End Of The Function Fft */


void PhaseShifting(void)
{
    double *tempr, *tempi;
    int k,num1;
    FILE *fp1;

    printf("\nPerforming phase shift ... ... ...\n");
```

```
    tempr = (double *)calloc(sizeof(double),row);
    tempi = (double *)calloc(sizeof(double),row);

    for ( k=0; k<=N; k++ )
    {
        tempr[k]=Gr[k];
        tempi[k]=Gi[k];
    }

    for ( k=0; k<=ceil(N/2); k++ )
    {
        Gr[k] = tempi[k];
        Gi[k] = -tempr[k];
    }

    for ( k=(int)ceil(N/2)+1; k<=N; k++ )
    {
        Gr[k] = -tempi[k];
        Gi[k] = tempr[k];
    }

    if(debug){
        if((fp1=fopen("ffrpt.bin","wb"))!=NULL)   {
            num1=fwrite(Gr,sizeof(double),row,fp1);
            fclose(fp1);
        }
        if((fp1=fopen("ffipt.bin","wb"))!=NULL)   {
            num1=fwrite(Gi,sizeof(double),row,fp1);
            fclose(fp1);
        }
    }

    free (tempr);
    free (tempi);
}/*End of PhaseShift() function*/


void Ifft(void)
{
    double *Gt_tmp; /* It takes the real part of R_ifft*/
    double *Gt_tmpi;
    FILE *fp1;
    int k,i,z1,num1;

    Gt_tmp = (double *)calloc(sizeof(double),row);
    Gt_tmpi = (double *)calloc(sizeof(double),row);

    printf("\nPerforming IFFT ... ... ...\n");

    for (k=0;k<=N;k++){
        Gt_ifft[k].r=Gr[k];
        Gt_ifft[k].i=Gi[k];
    }

    z1=ziffts(fftdebug,Gt_ifft,row);/*IFFT of the signal in spatial coordinate*/

    printf("\nEnd of IFFT ... ...\n");

    for (k=0;k<=N;k++) {
        Gt_tmp[k]=Gt_ifft[k].r;
```

```
    }

    if(debug){
    fp1=fopen("ifft.txt","w");
 if (!fp1)
 fprintf(stdout,"Cann't write in %s\n",fp1);
 for(i=0; i<=N; i++)
 fprintf(fp1,"%.4e\n",(Gt_ifft[i].r));
 fclose(fp1);
 }

    printf("\nPerforming IFFT writing... ... ...\n");

    if(debug){
        if((fp1=fopen("iffrpt.bin","wb"))!=NULL)  {
            num1=fwrite(Gt_tmp,sizeof(double),row,fp1);
            fclose(fp1);
        }
        if((fp1=fopen("iffipt.bin","wb"))!=NULL)  {
            num1=fwrite(Gt_tmpi,sizeof(double),row,fp1);
            fclose(fp1);
        }
    }

 free(Gt_tmp );
 free(Gt_tmpi );
}/* End Of Function Ifft*/

int EnvelopeReconstruction(void)
{
    FILE *fp1;
    int k;

    doublecomplex *G; /*Input signal readed from input file in complex form*/
    doublecomplex *Ganalytical;/*Analytical function of our input signal*/

    double *test;
    double *sqrtr;
    double *sqrti;

    G.= (doublecomplex *)calloc(sizeof(doublecomplex),row);
    Ganalytical = (doublecomplex *)calloc(sizeof(doublecomplex),row);

    test = (double *)calloc(sizeof(double),row);
    sqrtr=(double *)calloc(sizeof(double),row);
    sqrti=(double *)calloc(sizeof(double),row);

    printf("\nPerforming envelope extraction ... ... ...\n");

    for (k=0;k<=N;k++){
        RE(G[k]) = Gvalue[k];
        IM(G[k]) = 0.0;
    }

    for (k=0;k<=N;k++){
        RE(Ganalytical[k])=G[k].r;
        IM(Ganalytical[k])=Gt_ifft[k].r;
    }

    for (k=0;k<=N;k++){
```

```
    sqrtr[k]=sqrt(Ganalytical[k].r*Ganalytical[k].r+Ganalytical[k].i*Ganalytical[k].i);
    }
        fp1=fopen("output.txt","w");
        if (!fp1)
        {
            fprintf(stdout,"Cann't write extracted envelope in output.txt.\n");
            free(G);
            free(Ganalytical);
            free(test);
            free(sqrtr);
            free(sqrti);
            return 1;
        }
        for(k=0; k<SampledPoints; k++)
            fprintf(fp1,"%e,%e\n",Gtime[k],sqrtr[k]);

        printf("\nExtracted envelope is written in %s\n","output.txt");
        fclose(fp1);

    free(G);
    free(Ganalytical);
    free(test);
    free(sqrtr);
    free(sqrti);
    return 0;
}

/*Main Function*/

int main(int argc, char *argv[])
{
    int status=0,i=1;
    char fname[256],c;

    if(argc==2)
    {
        printf("\nInput File Name: ");
        //scanf("%s,InputFileName");
        strcpy(fname, argv[1]);
        InputFileName= fname;
        printf("%s\n",InputFileName);
    }
    else
    {
    printf("\nUse default file : %s\n", InputFileName);

    }

    //Reading the sampled data

    do
    {
        N=(int)pow(2,i)-1;
        i++;

    }while (MAX_POINT > N);

    if (debug)
    {
```

```
    printf("N= %d\n",N);
    }

    row=N+1;

    Gvalue = (double *)calloc(sizeof(double),row);
    Gtime = (double *)calloc(sizeof(double),row);
    Gr = (double *)calloc(sizeof(double),row);
    Gi = (double *)calloc(sizeof(double),row);
    Gt_ifft= (doublecomplex *)calloc(sizeof(doublecomplex),row);
    Gc = (double *)calloc(sizeof(double),row);

    status = ReadData();
    if (status== 1) goto MainExit;
    /*Does FFT*/
 Fft();
    /*Appropriate Phahe has been Shifted*/
 PhaseShifting();
    /*Does IFFT*/
 Ifft();
    /*Envelope Reconstruction */
 status = EnvelopeReconstruction();
    if (status== 1) goto MainExit;
    printf("\n\n==================================\n\n");
    printf("Input file name : %s \n",InputFileName);
    //printf("Gvalue[] has the input value\n");
    //printf("sqrtr[] has the output value\n");
    printf("Output file name output.txt\n");
    printf("\n==================================\n\n");

    MainExit:
    free(Gvalue);
    free(Gtime);
    free(Gr);
    free(Gi);
    free(Gt_ifft);
    free(Gc);
    printf("\n\nPress any key to exit.\n");

    scanf("%c",&c);

    return (0);
}/*End Of Main*/



/*****************************************************************************************/
/*fftrm.h                                                */
/*This is the header file for fftrm.c */
/*****************************************************************************************/

#ifndef FFTRM_H
#define FFTRM_H


#define RE(z) ((z).r)
#define IM(z) ((z).i)

typedef float real;
typedef double doublereal;
```

```
typedef struct { real r, i; } complex;
typedef struct { doublereal r, i; } doublecomplex;

int zffts (int debug, doublecomplex *X, int M);
int ziffts (int debug, doublecomplex *X, int M);
void zfftrmc(doublecomplex *X, int M, int P, float D);
void rmpo (int *rv, int *rvp );

#endif


/*****************************************************************************************/
/*fftrm.c                                                    */
/*This code contains the necessary function for fourier and inverse fourier transformation*/
/*****************************************************************************************/


#include <stdio.h>
#include <math.h>
#include <malloc.h>
#include "fftrm.h"
//#ifndef M_PI
#define M_PI 3.14159265358979323846264338327 95
//#endif

float *WR;
float *WI;

doublereal *DWR;
doublereal *DWI;

void rmpo( int *rv, int *rvp )

{
 intvalue_h;
 intn;

 n   = 1;
 *rvp = -1;
 value_h = 1;

 while ( value_h > 0 ) {

 value_h = *rv - n;

 (*rvp)++;

 n += n;
 }
}


void zfftrmc( doublecomplex *X, int M, int P, float D )
{
 int MV2,MM1,J,I,K,L,LE,LE1,IP,IQ,IND,IND1,R;
 int I1,J1,IPOTR;

 float A,B;
 float WCOS,WSIN;
 float VR,VI;
```

```
 float ARG;

 static int IPOTC;
 static float DALT;

 IPOTR = 0;

 DWR = (doublereal *)calloc(M,sizeof(doublereal));
 DWI = (doublereal *)calloc(M,sizeof(doublereal));

/* if (IPOTC == P & D == DALT) goto warmstart; */

 IPOTC = P;
 DALT   = (float)D;
 LE = 1;
 IND= 0;

 for (L=1;L<=P;L++) {
 LE1 = LE;
 LE  = LE*2;
 DWR[IND] = 1.0;
 DWI[IND] = 0.0;
 ARG.= (float)M_PI/(float)LE1;
 WCOS = (float)cos(ARG);
 WSIN = (float)(D*sin(ARG));

 for (R=1;R<=LE1;R++) {
 IND1 = IND+1;
 A = (float)DWR[IND];
 B = (float)DWI[IND];
 DWR[IND1] = A*WCOS - B*WSIN;
 DWI[IND1] = B*WCOS + A*WSIN;
 ++IND;
 }
 }

 /* warmstart: */

 MV2=M/2;
 MM1=M-1;
 J=1;

 for (I=1; I<=MM1; I++) {
 if (I >= J)
 goto P1;

 J1  = J-1;
 I1  = I-1;

 VR  = (float)RE(X[J1]);
 VI  = (float)IM(X[J1]);

 RE(X[J1]) = RE(X[I1]);
 IM(X[J1]) = IM(X[I1]);

 RE(X[I1]) = VR;
 IM(X[I1]) = VI;

P1: K    = MV2;
P2: if (K >= J) goto P3;
```

```
 J = J-K;
 K = K/2;
 goto P2;
P3: J = J+K;

 }

 IND = 0;
 LE = 1;

 for (L=1; L<=P; L++) {
 LE1 = LE;
 LE = LE*2;

 for (R=0; R<LE1; R++) {
 WCOS = (float)DWR[IND];
 WSIN = (float)DWI[IND];
 IND = IND+1;

 for (IQ=R; IQ<M; IQ+=LE) {

    IP = IQ+LE1;

    A = (float)RE(X[IP]);
    B = (float)IM(X[IP]);

    VR = A*WCOS - B*WSIN;
    VI = B*WCOS + A*WSIN;

    RE(X[IP]) = RE(X[IQ]) - VR;
    IM(X[IP]) = IM(X[IQ]) - VI;

    RE(X[IQ]) = RE(X[IQ]) + VR;
    IM(X[IQ]) = IM(X[IQ]) + VI;
 }
 }
 }

 free(DWR);
 free(DWI);
}

/*=========================================================================*/
/*___1-D FFT with respect to a spatial coordinate_____________________________*/
/*=========================================================================*/
int zffts( int debug, doublecomplex *X, int M )
{
 int P;
 float D;

 D = -1.0;

 rmpo( &M, &P);

 if ( debug ) {
 printf("P = %d\n",P);
 printf("FFT ...\n");
 }

 zfftrmc( X, M, P, D); /* fftrm.c */
```

```
 return 0;
}

/*=========================================================================*/
/*___1-D Inverse FFT with respect to a spatial coordinate_____________________*/
/*=========================================================================*/
int ziffts( int debug, doublecomplex *X, int M )
{
 int i;
 int P;
 float D;

 D = 1.0;

 rmpo( &M, &P);

 if ( debug ) {
 printf("P = %d\n",P);
 printf("IFFT ...\n");
 }

 zfftrmc( X, M, P, D); /* fftrm.c */

 /*___Multiply with 1/M____*/

 for (i=0; i<M; i++) {
 RE(X[i]) /= (doublereal)M;
 IM(X[i]) /= (doublereal)M;
 }

 return 0;
}/*End of fftrm.c*/
```