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Radiofrequency identification of animals —

Part 3: Evaluation of performance of RFID transponders conforming with ISO 11784 and ISO 11785

Identification des animaux par radiofréquence —

Partie 3: Évaluation de la performance des transpondeurs RFID conformes à l'ISO 11784 et à l'ISO 11785

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Contents

Page

Foreword iv
Introduction v
1 **Scope** 1
2 **Conformance** 1
3 **Normative references** 1
4 **Terms and definitions** 2
5 **Abbreviated terms** 4
6 **Application** 4
7 **Test procedures** 5
7.1 **General** 5
7.2 **Helmholtz configuration** 5
7.3 **Test apparatus** 11
7.4 **Test set-ups for measuring the modulation amplitude** 12
7.5 **Test conditions** 13
7.6 **Tests** 13
Annex A (normative) **Test application form** 26
Annex B (informative) **Current source transmitter** 27
Bibliography 28

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member 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 shall not be held responsible for identifying any or all such patent rights.

ISO 24631-3 was prepared by Technical Committee ISO/TC 23, *Tractors and machinery for agriculture and forestry*, Subcommittee SC 19, *Agricultural electronics*.

ISO 24631 consists of the following parts, under the general title *Radiofrequency identification of animals*:

— *Part 1: Evaluation of conformance of RFID transponders with ISO 11784 and ISO 11785 (including granting and use of a manufacturer code)*

— *Part 2: Evaluation of conformance of RFID transceivers with ISO 11784 and ISO 11785*

— *Part 3: Evaluation of performance of RFID transponders conforming with ISO 11784 and ISO 11785*

— *Part 4: Evaluation of performance of RFID transceivers conforming with ISO 11784 and ISO 11785*

Introduction

ISO has appointed ICAR (International Committee for Animal Recording) as the registration authority (RA) competent to register manufacturer codes used in the radiofrequency identification (RFID) of animals in accordance with ISO 11784 and ISO 11785.

ISO 24631 defines means, based upon ICAR test procedures [1], for evaluating and verifying both the conformance and performance of RFID devices in respect of ISO 11784 and ISO 11785. Only those results emanating from RA-approved test centres are recognized.

This part of ISO 24631 deals with the performance of RFID transponders, of which the four main types used for animal identification are

- injectable transponders,
- electronic ear tag transponders,
- electronic ruminal bolus transponders, and
- tag attachments.

This part of ISO 24631 permits the characterization of the two RFID communication paths: the energy transfer from transceiver to transponder, and the data transfer from transponder to transceiver. This characterization can be obtained from the results of two measurements — the first determining the minimal activating magnetic field strength needed for transmitting the information and the second the transponder modulation amplitude. Both measurements use a reference measurement antenna configuration under conditions allowing the absolute values to be obtained for comparison of data between the tested transponders. Additional measurements that contribute to the performance assessment of the transponders are the bit length stability in the case of FDX-B transponders and the frequency stability in the case of HDX transponders. These parameters can be measured using the same measurement antenna configuration.

Radiofrequency identification of animals —

Part 3: Evaluation of performance of RFID transponders conforming with ISO 11784 and ISO 11785

1 Scope

This part of ISO 24631 provides the means of evaluating the performance of ISO 11784- and ISO 11785-conformant RFID (radiofrequency identification) transponders used in the individual identification of animals.

The test procedures specified in this part of ISO 24631 are recognized by the FECAVA (Federation of European Companion Animals Veterinary Association) and WSAVA (World Small Animal Veterinarian Association) and as such can be applied also to companion animals.

2 Conformance

Test centres approved by the registration authority (RA) shall perform transponder testing using the procedures specified in Clause 7 and shall report the test results to the RA. These tests are in accordance with the technical requirements of ISO 11784 and ISO 11785. The manufacturer shall apply for transponder testing by completing and submitting to the RA the application form provided in Annex A. Only transponders with a product code issued by the RA (see ISO 24631-1) shall be tested. A transponder test report shall be accorded to a manufacturer whose transponder product has been tested as per Clause 7.

3 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 3166-1, *Codes for the representation of names of countries and their subdivisions — Part 1: Country codes*

ISO 11784, *Radio frequency identification of animals — Code structure*

ISO 11785:1996, *Radio frequency identification of animals — Technical concept*

ISO 24631-1:2009, *Radiofrequency identification of animals — Part 1: Evaluation of conformance of RFID transponders with ISO 11784 and ISO 11785 (including granting and use of a manufacturer code)*

ERC recommendation 70-03, *Relating to the Use of Short Range Devices* (SRD)[1]

1) CEPT (Conférence Européenne des Administrations des Postes et des Télécommunications) publication.

4 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

4.1
bit length stability
stability of an FDX-B transponder expressed by the standard deviation of the duration of one-bit information

4.2
country code
three-digit numeric code representing a country in accordance with ISO 3166-1

4.3
frequency stability
stability of an HDX transponder expressed by the standard deviation of the two frequencies representing the low and high bit of an FSK modulated signal

4.4
identification code
code used to identify the animal individually, at the national and, in combination with a country code, international levels

NOTE It is a national responsibility to ensure the uniqueness of national ID codes.

4.5
laboratory activation field
electromagnetic field with a frequency of 134,2 kHz and a magnetic field strength according to ERC Recommendation 70-03

4.6
laboratory reference transceiver
transceiver used to test the transponders generating the laboratory activation field, able to read FDX-B and HDX transponders

4.7
manufacturer
company that submits an application for conformance testing or for the granting and use of a manufacturer code for transponders in conformance with ISO 11784 and ISO 11785 while accepting the conditions set forth in ISO 24631-1:2009, Annexes B, C and E

4.8
manufacturer code
MFC
three-digit number granted by the RA to a manufacturer under the conditions set forth in ISO 24631-1:2009, Annex E, whose range and placement within the code structure are in accordance with ISO 11784

NOTE Only one manufacturer code is granted to the same manufacturer.

4.9
product code
six-digit number granted by the registration authority to a manufacturer for a certain type of transponder, formatted such that its first part is the manufacturer code and second part a three-digit serial number

4.10
RA-approved test centre
accredited test centre meeting the criteria of the registration authority

NOTE Accreditation: third-party attestation related to a conformity assessment body conveying formal demonstration of its competence to carry out specific conformity assessment tasks (see Reference [2]).

4.11
RA-approved transponder
transponder approved by the registration authority

4.12
RA-registered manufacturer
manufacturer with one or more RA-approved transponders

4.13
registration authority
RA
entity that approves test laboratories and issues and registers manufacturer and product codes

4.14
retagging
process that assigns to a new transponder the same identification number as a transponder that has been lost or that is no longer readable

4.15
retagging counter
three-bit field for counting the number of retagging

4.16
transceiver
device used to communicate with the transponder

4.17
transponder
radio frequency identification (RFID) device that transmits its stored information when activated by a transceiver and that may be able to store new information

NOTE A transponder can be characterized according to its components (chip, coil, capacitor, etc.), communication protocol, size, shape and packaging, or any additional characteristics that could change its properties. The main types are defined in 4.17.1 to 4.17.4 below.

4.17.1
injectable transponder
small transponder able to be injected into an animal's body and encapsulated in a biocompatible and non-porous material such as glass

4.17.2
electronic ear tag transponder
plastic-covered transponder able to be fixed to the ear of the animal using a locking mechanism or to be attached to an ear tag such that it cannot be removed from the tag without damaging it

4.17.3
electronic ruminal bolus transponder
transponder placed into a high specific gravity container able to be orally administered to a ruminant, which remains permanently in its fore stomach

4.17.4
tag attachment
transponder components covered by a primary protection layer and meant for producing one or more of the three other main transponder types or other types of animal transponder

4.18
transponder modulation amplitude
characterization of the transponder signal strength sent back to the transceiver

NOTE For FDX-B it corresponds to the modulation depth; for HDX to the average voltage depth.

4.19
transponder minimal activating magnetic field strength
minimal value of magnetic field strength needed to obtain full activity of the transponder

NOTE The transponder is activated after having been placed in a magnetic field whose strength depends on the antenna, chip and packaging design. Full activity is obtained when the transponder is supplied with energy sufficient to transmit the complete data according to ISO 11785.

4.20
user information field
five-bit field for additional user information, used only in conjunction with the country code

5 Abbreviated terms

CN	compensating network
CRC	cyclic redundancy check
FDX-B	full duplex communication protocol (conforming to ISO 11785, excluding protocols mentioned in ISO 11785:1996, Annex A)
FSK	frequency shift keying
HDX	half duplex communication protocol
HSC	Helmholtz sensing coil
HTA	Helmholtz transmitting antenna
IEEE	Institute of Electrical and Electronics Engineers
MFC	manufacturer code
MN	matching network
RA	registration authority
RFID	radiofrequency identification
SC	sensing coil
TUT	transponder under test

6 Application

6.1 The application submitted to the RA for testing the performance of a transponder shall consist of a covering letter and the application form presented in Annex A. The RA shall confirm receipt of the application to the manufacturer within two weeks. By signing the application form, the manufacturer agrees to fulfil the provisions of this part of ISO 24631.

6.2 Approval in accordance with ISO 24631-1 is a prerequisite for approval for testing in accordance with the present part of ISO 24631.

6.3 The test centre shall be approved by the RA.

6.4 The RA maintains a list of approved test centres, from which the manufacturer may choose the centre that will test his transponder product.

6.5 The manufacturer shall provide the RA-approved test centre with 50 transponders of the same type and model for testing. If the RA-approved test centre selected already has this number of the same transponders, they may be used. The transponders shall carry the country code “999” (indicating a test transponder) or the manufacturer’s code if existent. The manufacturer may freely choose the identification codes, but duplicated numbers are not allowed. The manufacturer shall provide a list of the transponder codes in decimal representation.

6.6 The RA-approved test centre shall verify the transponders using the test procedures specified in Clause 7. All tested transponders shall be readable by the configuration also specified in Clause 7. The codes read shall match the codes provided by the manufacturer.

6.7 The RA-approved test centre shall prepare a confidential report of the results and shall send two copies (and an electronic version) of the report to the chairman of the RA.

6.8 The RA chairman shall inform the manufacturer of the test results in a letter together with a copy of the report.

6.9 The tested transponders shall be kept by the RA-approved test centre, under the ownership of the RA.

6.10 The RA shall make publicly available a photograph of the approved transponder.

6.11 The RA shall make publicly available the main results of the test. A manufacturer shall have the right to refuse that the results be made publicly available or to request their withdrawal from public availability. In the first case, the manufacturer shall send a request to the RA not to publish, within two weeks of having received the test report. In the second, the manufacturer shall send a request to the RA and the RA shall remove the results from public availability within four weeks of receipt of this request.

6.12 The RA shall do everything within its power to protect the integrity of this procedure with regard to ISO 11784 and ISO 11785.

7 Test procedures

7.1 General

The test centre shall test five transponders randomly picked from the 50 transponders provided by the manufacturer, in accordance with the following procedures. During the measurements, the transponder shall be positioned in a Helmholtz configuration producing an adjustable uniform magnetic field.

7.2 Helmholtz configuration

7.2.1 Transponder parameter test set-up

The Helmholtz transmitting antennas (HTA) produce a homogeneous, cylindrically shaped field. A functional diagram of the Helmholtz configuration and corresponding test set-up is shown in Figure 1. The transponder under test (TUT) shall be positioned on the central axis, midway between the transmitter coils of the test configuration.[2] The matching network (MN) shall be used to match the setup of the two HTA to 50 Ω output resistance of the amplifier.

2) The maximum size of the transponder is limited by the Helmholtz configuration's dimensions — in length by the distance between the HTA, and in diameter by the HSC diameter. The signal emitted by small transponders could require smaller sensing coil dimensions. If that is the case, the ISO/TC 23/SC 19 animal identification working group will develop a special setup for those devices.

7.2.2 Field strength calculation

A very accurate relation exists between the magnetic field and the current in the Helmholtz coils. By measuring the current through the HTA, the magnetic field strength, H_{rms} (root mean square, 35,8 mA/m – 35,8 A/m) can be calculated from Equation (1):

$$H_{rms} = \frac{N_{HTA} \times U_{HTA\_pp}}{1{,}976\,4 \times D_{HTA} \times R_{HTA}} \tag{1}$$

where

N_{HTA} is the number of turns on HTA coil (= 5);

U_{HTA_pp} is the peak-to-peak voltage at R_{HTA};

D_{HTA} is the diameter of HTA coil;

R_{HTA} is the resistor in series with HTA coils.

7.2.3 Helmholtz transmitting antenna (HTA) coils

The dimensions and characteristics of the HTA coils shall be as shown in Figure 2.

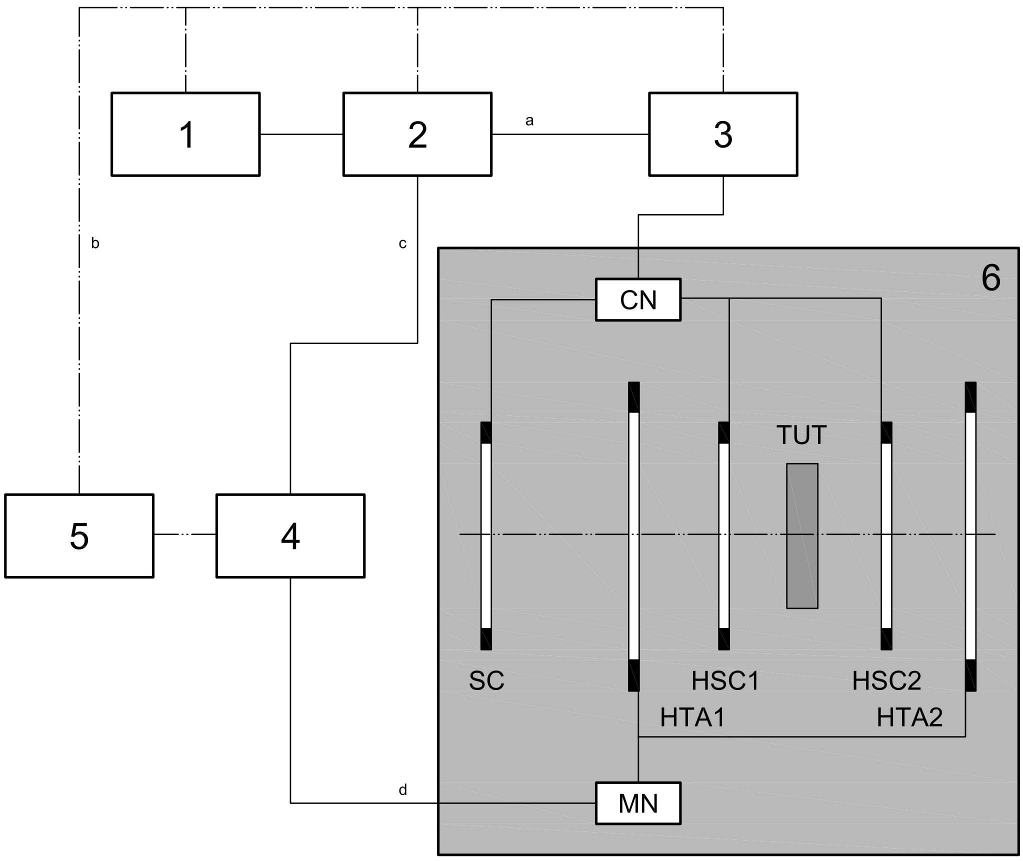
Two HTA coils are used in the Helmholtz configuration.

Owing to the low number of turns (five), the best way to manufacture the HTA is by winding onto a core element.

7.2.4 Helmholtz sensing coils (HSC) and sensing coils (SC)

HSC shall be used for both FDX-B and HDX. Two HSC shall be connected in series.

The HSC and the SC shall be made in accordance with Figure 3 and shall be connected by means of the compensation network (CN) (see Figure 1).



Key

1 code generator

2 function waveform or arbitrary waveform generator

3 oscilloscope

4 amplifier

5 personal computer (PC) with IEEE card

6 measurement antenna configuration

CN compensation network

HSC1 first Helmholtz sensing coil [e]

HSC2 second Helmholtz sensing coil [e]

HTA1 first Helmholtz transmitting antenna [e]

HTA2 second Helmholtz transmitting antenna [e]

MN matching network

SC sensing coil

TUT transponder under test

[a] Trigger.

[b] IEEE interface.

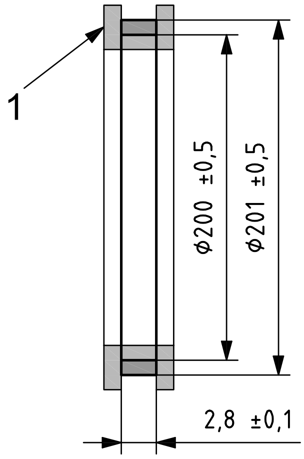
[c] Output signal.

[d] 50 Ω.

[e] Serial and in phase.

Figure 1 — Test set-up and Helmholtz configuration

Dimensions in millimetres



Key

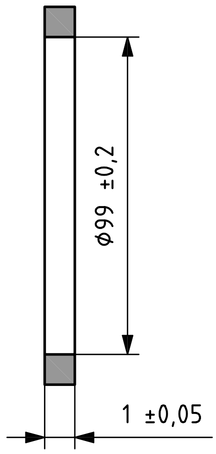
1 core element

Wire: B155 500 µm Grade 1B

N_{HTA} (number of turns on HTA) = 5

Figure 2 — HTA coils — Physical characteristics

Dimensions in millimetres



Wire: B155 100 µm Grade 1B or P155 100 µm Grade 2

N_{HSC} (number of turns on HSC) = 70

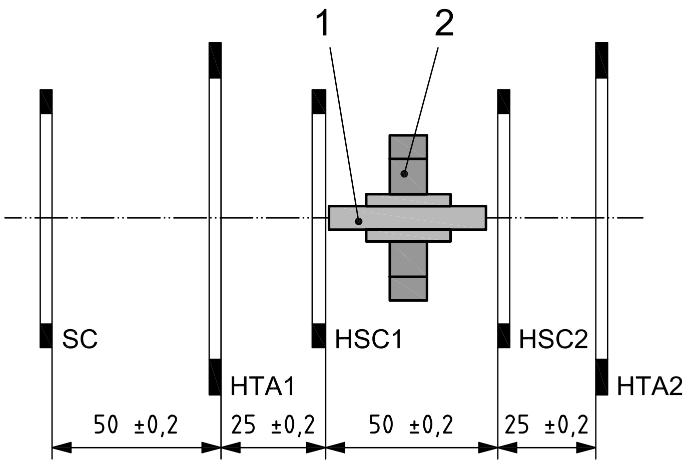
N_{SC} (number of turns on SC) = 45

Figure 3 — HSC and SC — Physical characteristics

7.2.5 Positioning HSC and SC in relation to HTA

The HSC shall be centred between the two HTA. The external SC, if needed, shall be positioned as shown in Figure 4.

Dimensions in millimetres



Key

1 ferrite coil

2 air coil

CN compensation network

HSC1 first Helmholtz sensing coil

HSC2 second Helmholtz sensing coil

HTA1 first Helmholtz transmitting antenna

HTA2 second Helmholtz transmitting antenna

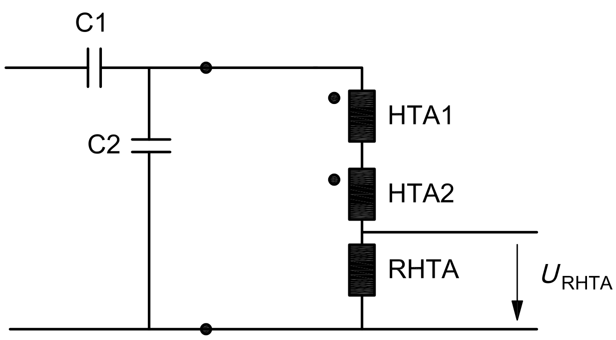
MN matching network

SC sensing coil

Figure 4 — HTA, HSC and SC positions

7.2.6 Matching network (MN)

The matching network shall be realized according to Figure 5 (see also Figure 1).



Key

C1, C2 capacitors

HTA1, HTA2 Helmholtz transmitting antennas

U_{RHTA} voltage at RHTA

RHTA resistor in series with HTA coils

Figure 5 — MN and magnetic field-generating coils

Capacitors C1 and C2 shall be adjusted (e.g. parallel capacitors) to match the resistor, RHTA , and HTA1 and HTA2 to 50 Ω of the amplifier output. Values for C1, C2 and RHTA shall be adjusted around the start values for 134,2 kHz in accordance with Table 1.

Table 1 — Matching components for 134,2 kHz

Component	Value	Comment
C1	15 nF	500 V, film capacitance
C2	30 nF	500 V, film capacitance
RHTA	5 Ω [a]	10 W, low inductance
[a] The value of 5 Ω for RHTA takes into account the series resistance of the HTA coils, which have an approximate value of 0,4 Ω.		

7.2.7 Matching network (MN)

The HTA shall be matched to the output impedance of the amplifier: 1 V into 50 Ω gives 1 A into the HTA coils.

In order to respect the inductance value of the HTA, which shall be 33 µH, the series capacitor value shall be 42 nF.

During the test, couple the transponder with the HTA and HSC.

For very small transponders, the coupling between the transponder coil and the HTA is very low and negligible.

For larger transponders, couple the HTA to the transponder for a given value: a part of the energy is absorbed in the calculated output resistor of 4,7 Ω of the transmitter. Only a transmitter that works as a current source possesses very high output resistance and is therefore without influence on the behaviour of the transponder.

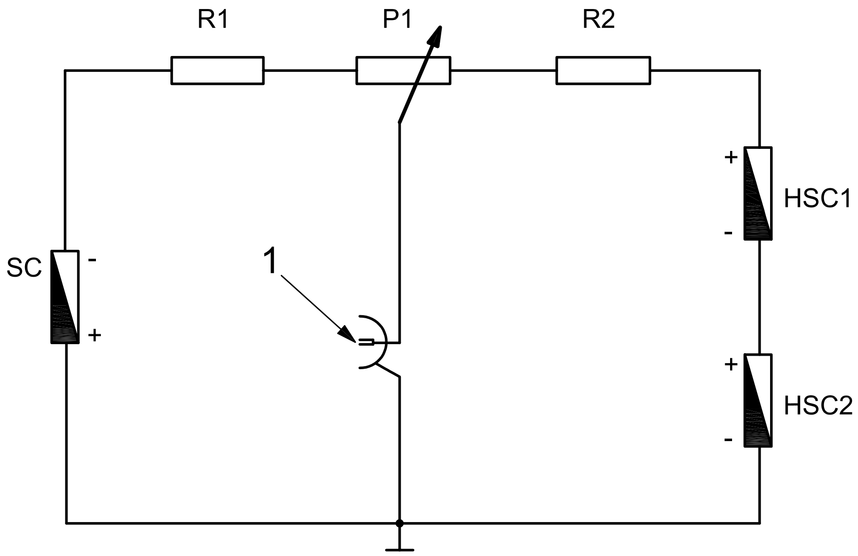
Another problem that can occur is detuning due to the coupling of these coils — resulting in distortion of the transponder code and a wrong measurement of the modulation amplitude.

Such problems can be avoided if a current source transmitter such as the one illustrated in Annex B is used.

7.2.8 Compensation network (CN)

The CN shall be used to zero out the constant magnetic field generated by the HTA and shall be built according to the schematic diagram shown in Figure 6. The adjustment potentiometer (P1) compensates for mechanical and electrical mismatches.

The oscilloscope probe used should have at least the characteristics: $\geqslant$ 10 MΩ and $\leqslant$ 20 pF.



Key

1 oscilloscope

HSC1 first Helmholtz sensing coil

HSC2 second Helmholtz sensing coil

P1 adjustment potentiometer (10 kΩ)

R1 first resistor (15 kΩ)

R2 second resistor (100 kΩ)

SC sensing coil

Figure 6 — Compensation network for zeroing out HTA magnetic field

7.3 Test apparatus

7.3.1 Magnetic field generation

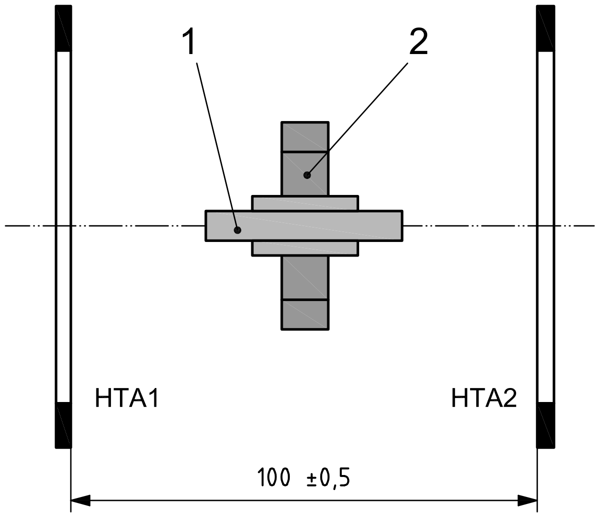
7.3.1.1 Helmholtz transmitting antenna (HTA) configuration, built in accordance with Figure 7.

7.3.1.2 Function waveform generator (FWG) or arbitrary waveform generator (AWG).

7.3.2 Matching network (MN), in accordance with 7.2.7.

7.3.3 Compensation network, in accordance with 7.2.8.

Dimensions in millimetres



Key

1 ferrite coil

2 air coil

HTA1 first Helmholtz transmitting antenna

HTA2 second Helmholtz transmitting antenna

Connect the two HTA in series.

Figure 7 — HTA configuration — Physical characteristics

7.3.4 Magnetic field modulation (FDX-B only)

7.3.4.1 Compensated field measurement coil configuration.

The compensated field measurement coil configuration uses three coils disposed in specific orientations. Two HSC collect the modulation magnetic field emitted by the transponder, while an SC collects the magnetic field, which is almost not modulated. Combining both the collected signals from the HSC and SC through the CN shall allow the nulling of the constant magnetic field generated by the HTA. This configuration is required in order to reduce the position sensitivity of the TUT.

7.3.4.2 Two-channel oscilloscope, with a bandwidth of at least 100 MHz.

7.3.4.3 Personal computer (PC), with an interface allowing full control of the instruments used — for example, by means of an IEEE interface.

7.4 Test set-ups for measuring the modulation amplitude

7.4.1 FDX-B transponders

The sensing of the modulation amplitude shall be performed using a three-coil configuration, consisting of two HSC placed into a Helmholtz configuration within the Helmholtz transmitting antennas, and one SC placed outside the Helmholtz transmitting antennas. The internal HSC shall sense the generated field and emitted modulation signal with low influence from the coupling factor and position of the transponder unit; the external SC shall sense only the generated field and can consequently be used as a compensation signal by subtracting the generated field. The output of the CN is the return signal of the transponder.

7.4.2 HDX transponders

The sensing of the modulation amplitude shall be performed using a two-coil configuration, consisting of two HSC placed into a Helmholtz configuration within the Helmholtz transmitting antennas. The HSC shall sense the generated field and the emitted frequencies with low influence from the coupling factor and position of the transponder unit, and shall deliver the bit value representing frequencies directly to the oscilloscope.

The external SC and CN shall remain connected, despite not having a functional impact on the HDX frequency measurements.

7.5 Test conditions

The test conditions shall be as follows.

Ambient temperature:	minimum 15 °C and maximum 30 °C
Ambient humidity:	minimum 40 % rH and maximum 80 % rH
Ambient noise floor and ambient peak noise:	< 30 dBμV/m (bandwidth 2,7 kHz) 50 Hz to 1 MHz during measurements

Special attention shall be given to spurious emissions, which can be emitted, for example, by insufficiently shielded computer monitors. The electromagnetic test conditions of the measurements shall be checked by carrying out the measurements both with and without a transponder in the field.

7.6 Tests

7.6.1 General

For a complete characterization of the TUT, perform all the tests. The transmitting pattern shall be generated in accordance with ISO 11785. The time sequence shall be such that the magnetic field is activated for a period of 50 ms, followed by a magnetic field interruption of 20 ms. See Figure 8.

7.6.2 Transponder orientation

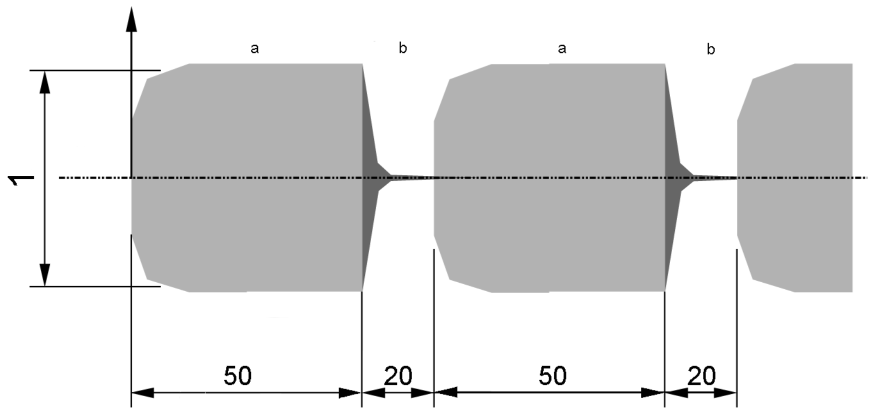
The system has been designed so that minor positioning errors shall not influence the measurements results. Nevertheless, in order to obtain reproducible measurements, the transponder position has to be well defined:

— in the case of an air-coil transponder, its orientation shall be parallel to the transmitting antenna plane;

— in the case of a ferrite-coil transponder, its orientation shall be perpendicular to the transmitting antenna plane.

See Figure 4.

Values in milliseconds



Key

1 activation field

[a] Field ON.

[b] Field OFF.

Figure 8 — Magnetic field activation sequence

7.6.3 Constant magnetic field nulling

The purpose of this test is to compensate for all mechanical and electrical mismatches of the measurement antenna configuration. It is necessary to use and adjust the CN prior to measurement in order to obtain the minimal noise level measured using the oscilloscope. The procedure, as follows, shall be repeated before each measurement series or after each mechanical intervention, equipment change or test location change.

a) Check all interconnections and switch on all equipment.

b) Set the waveform generator to product a 134,2 kHz continuous sine wave.

c) Set the antenna current to obtain a magnetic field strength of 1 A/m.

d) Adjust the potentiometer (P1) to obtain the minimal voltage noise measured on the oscilloscope (for FDX-B)

e) Set the antenna current to obtain a magnetic field strength of 0,1 A/m.

f) Measure the voltage noise with the oscilloscope.

g) Set the antenna current to obtain a magnetic field strength of 10 A/m.

h) Measure the voltage noise with the oscilloscope.

i) If measurements f) and h) show more than 10 %, recheck the measurement configuration set-up both mechanically and electrically.

j) Record the following for each measurement:

   1) Test type residual noise level

   2) Magnetic field value 0,1 A/m, 1 A/m and 10 A/m

3) Waveform generator frequency in kilohertz

4) RMS noise level in millivolts

5) Ambient temperature in degrees Celsius

6) Ambient humidity (relative value) as a percentage

7.6.4 Minimal activating magnetic field strength in FDX-B mode

The purpose of this test is to determine the minimal magnetic field strength values for which the transponder will transmit a complete valid data sequence. It is necessary that the oscilloscope data be processed by the PC so that the identification code can be read out from the received data stream. The code has to be complete and checked against the CRC information, then sent inside a time window corresponding to the theoretical maximal acceptable [(30,52 ± 0,03) ms, in step e), of the following procedure].

a) Check that the constant magnetic field nulling procedure (7.6.3) has been carried out.

b) Set the waveform generator to 134,2 kHz and generate an interrogation pattern in accordance with ISO 11785.

c) Set the antenna current to 1 mA.

d) Record the voltage pattern measured on the CN with the oscilloscope over 100 ms.

e) Process the data stream to extract the identification code, which shall be sent inside a time window of (30,52 ± 0,03) ms.

f) If the identification code has not been extracted repeat 1) to 3) below until it has been extracted.

  1) increase the antenna current by 1 mA;

  2) record the voltage pattern measured on the CN with the oscilloscope over 30,52 ms;

  3) process the data stream to extract the identification code, which has to be sent inside the time window of (30,52 ± 0,03) ms.

g) If the identification code has been extracted, calculate the corresponding magnetic field strength value.

h) Record the identification code and its corresponding minimal activating magnetic field strength.

i) Record the following for each measurement:

  1) Test type minimal activating magnetic field strength in FDX-B mode

  2) Waveform generator frequency in kilohertz

  3) Identification code

  4) Minimal activating magnetic field value in amperes per metre

  5) Ambient temperature in degrees Celsius

  6) Ambient humidity (relative value) as a percentage

7.6.5 Minimal activating magnetic field strength in HDX mode

The purpose of this test is to define the minimal magnetic field strength values for which the transponder transmits a complete valid data sequence. It is necessary that the oscilloscope data be processed by the PC in such a way that the identification code can be read out from the received data stream. The code has to be complete and checked against the CRC information, then sent inside a time window corresponding to the theoretical maximal acceptable [20 ms, in step d) of the following procedure].

a) Set the waveform generator to 134,2 kHz and generate an interrogation pattern for HDX in accordance with ISO 11785.

b) Set the antenna current to 1 mA.

c) Record the voltage pattern measured on the HSC with the oscilloscope over 20 ms.

d) Process the data stream to extract the identification code, which shall be sent inside a time window of 20 ms.

e) If the identification code has not been extracted, increase the antenna current by 1 mA and repeat steps c) and d).

f) Record the identification code and its corresponding minimal activating magnetic field strength.

g) Record the following for each measurement:

1)	Test type	minimal activating magnetic field strength in HDX mode
2)	Waveform generator frequency	in kilohertz
3)	Identification code	
4)	Minimal activating magnetic field value	in amperes per metre
5)	Ambient temperature	in degrees Celsius
6)	Ambient humidity (relative value)	as a percentage

7.6.6 Modulation amplitude in FDX-B mode

The purpose of this test is to determine the transponder's modulation amplitude from the minimal activating field strength value up to a magnetic field strength value of 50 A/m. It is necessary that the oscilloscope data be processed by the PC such that both the high and low voltage levels of the received data stream can be defined. To obtain a more stable value, the transition period between the high and low level or the reverse should not be considered (see Figure 9), so that for calculation purposes the four clock frequency cycles after any transition are removed. The final value has to consider five low and five high level bit patterns representing a logical “1” [step d) of the following procedure].

Calculate the high and low level (U_{high} and U_{low}) values using Equations (2) and (3) respectively:

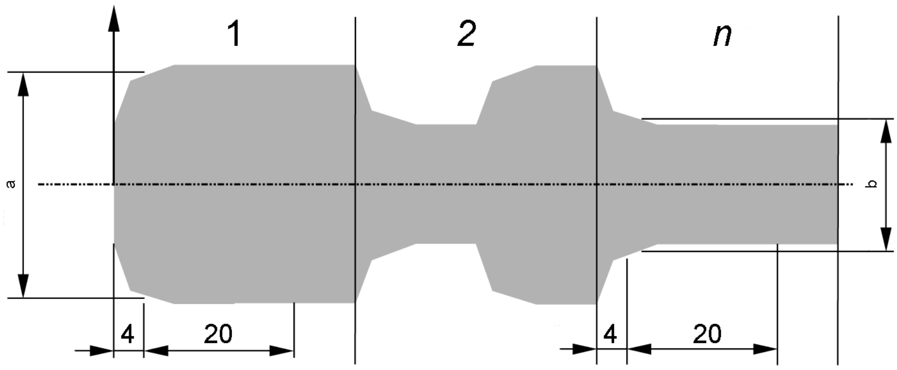
$$U_{\text{high}} = \frac{\sum_{\text{bit}1}^{\text{bit}5} \frac{\sum_{\text{cycle}5}^{\text{cycle}24} U_{\text{high\_pp\_cycle}}}{20}}{5} \qquad (2)$$

where $U_{\text{high\_pp\_cycle}}$ is the high voltage level peak-to-peak value of one cycle.

$$U_{\text{low}} = \frac{\sum_{\text{bit1}}^{\text{bit5}} \frac{\sum_{\text{cycle5}}^{\text{cycle24}} U_{\text{low\_pp\_cycle}}}{20}}{5} \qquad (3)$$

where $U_{\text{low\_pp\_cycle}}$ is the high voltage level peak-to-peak value of one cycle.

Values in number of clock frequency cycles



Key

1 bit 1 (1)

2 bit 2 (0)

n bit *n* (1)

a High level average.

b Low level average.

Figure 9 — Cycles used to calculate FDX-B modulation amplitude

a) Check that the constant magnetic field nulling procedure (7.6.3) has been carried out.

b) Set the waveform generator to 134,2 kHz and generate an interrogation pattern in accordance with ISO 11785.

c) Set the antenna current to obtain the minimal activating magnetic field strength.

d) Record the voltage pattern measured on the CN with the oscilloscope over five low and five high level bit patterns representing a logical “1”.

e) Process the data stream to extract the U_{high} and U_{low} values.

f) Calculate the modulation amplitude of the FDX-B transponder, $U_{\text{MA\_FDX}}$, at the corresponding magnetic field strength: $U_{\text{MA\_FDX}} = U_{\text{high}} - U_{\text{low}}$.

g) Create a result table in accordance with Table 2 as well as a graphical presentation of the results.

Table 2 — FDX-B modulation amplitude measurement results

Magnetic field strength A/m	U_{high} V	U_{low}	U_{MA_FDX}
Minimal activating value	X	Y	X–Y
…	…	…	…
50	R	S	R–S

h) Increase the magnetic field strength by 10 measuring points per decade and repeat the measurement until the table is completed.

i) Record the following for each measurement:

1) Test type — modulation amplitude in FDX-B mode

2) Waveform generator frequency — in kilohertz

3) Identification code:

4) Magnetic field value — in amperes per metre

5) U_{high} — in volts

6) U_{low} — in volts

7) U_{MA_FDX} — in volts

8) Results table — as per Table 2

9) Graphic representation of results — similar to Figure 12

10) Ambient temperature — in degrees Celsius

11) Ambient humidity (relative value) — as a percentage

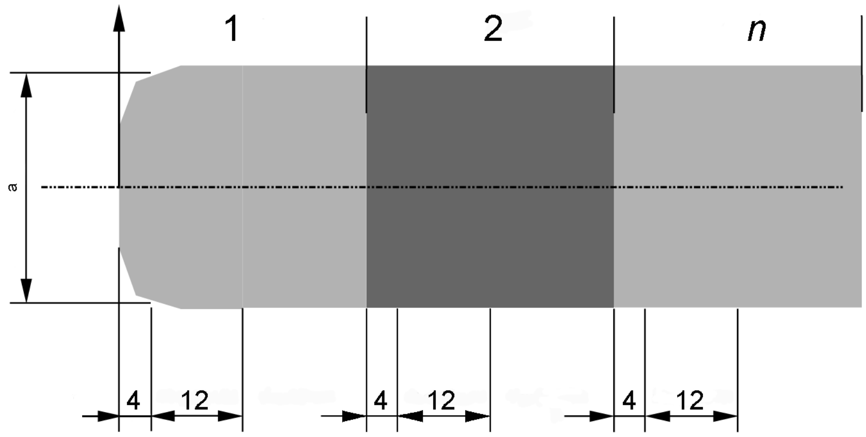
7.6.7 Modulation amplitude in HDX mode

The purpose of this test is to determine the transponder's modulation amplitude from the minimal activating field strength value up to a magnetic field strength value of 50 A/m. It is necessary that the oscilloscope data be processed by the PC such that the voltage level of the received data stream can be defined. The final value has to consider 10 consecutive bits starting 10 ms after the start of the header [see Figure 10 and step c) of the following procedure]. Calculate the high voltage level (U_{high}) value using Equation (4):

$$U_{high} = \frac{\sum_{bit1}^{bit10} \frac{\sum_{cycle5}^{cycle16} U_{high\_pp\_cycle}}{12}}{10} \quad (4)$$

where $U_{high\_pp\_cycle}$ is the high voltage level peak-to-peak value of one cycle.

Values in number of clock frequency cycles



Key

1 bit 1 (1)

2 bit 2 (0)

n bit *n* (1)

a High level average.

Figure 10 — Cycles used to calculate HDX modulation amplitude

a) Set the waveform generator to 134,2 kHz and generate an interrogation pattern in accordance with ISO 11785.

b) Set the antenna current to obtain the minimal activating magnetic field strength.

c) Record the voltage pattern measured on the HSC with the oscilloscope over 10 consecutive bits following 10 ms after the rising edge of the starting byte.

d) Process the data stream to extract the U_{high} value.

e) Calculate the modulation amplitude of the HDX transponder, U_{MA_HDX}, at the corresponding magnetic field strength: $U_{MA\_HDX} = U_{high}$.

f) Create a result table in accordance with Table 3 as well as a graphical presentation of the results.

Table 3 — HDX modulation amplitude measurement results

Magnetic field strength A/m	U_{MA_HDX} V
Minimal activating value	X
…	…
50	R

g) Increase the magnetic field strength by 10 measuring points per decade and repeat the measurement until the table is completed.

h) Record the following for each measurement:

1) Test type — modulation amplitude in HDX mode
2) Waveform generator frequency — in kilohertz
3) Identification code
4) Magnetic field value — in amperes per metre
5) U_{high} — in volts
6) $U_{\text{MA\_HDX}}$ — in volts
7) Results table — as per Table 3
8) Graphic representation of results — similar to Figure 12
9) Ambient temperature — in degrees Celsius
10) Ambient humidity (relative value) — as a percentage

7.6.8 Bit length stability in FDX-B mode

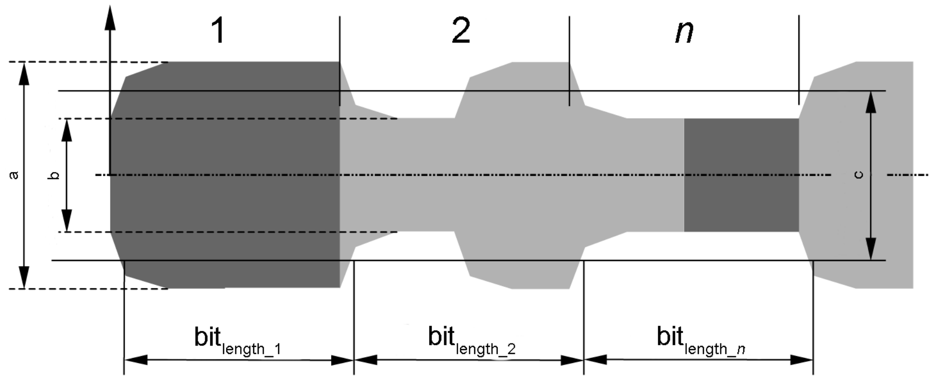
The purpose of this test is to determine the stability of the individual bit length. This value is related to the standard deviation of the time needed for transmitting 1 bit of information. The value depends on the magnetic field strength and therefore shall be measured from the minimal activating field strength value up to a magnetic field strength value of 50 A/m. It is necessary that the oscilloscope data be processed by the PC so that the bit length time can be defined [see Figure 11 and step e) of the following procedure). The bit length time, as well as its related stability, are defined at 50 % modulation level and over 128 consecutive bits [step d) below]. The average bit length ($\text{bit}_{\text{length}}$) and the bit stability ($\text{bit}_{\text{stability}}$), expressed in microseconds (µs), are calculated [step f) below] using Equations (5) and (6) respectively:

$$\text{bit}_{\text{length}} = \frac{\sum_{\text{bit}\,n=1}^{\text{bit}\,128} \text{bit}_{\text{length}\_n}}{128} \quad (5)$$

where $\text{bit}_{\text{length}\_n}$ is the length of one bit.

$$\text{bit}_{\text{stablity}} = 3\sqrt{\frac{\sum_{\text{bit}\,n=1}^{\text{bit}\,128} \left(\text{bit}_{\text{length}\_n} - \text{bit}_{\text{length}}\right)^2}{n-1}} \quad (6)$$

where n is the number of bits.



Key

1	bit 1 (1)
2	bit 2 (0)
n	bit *n* (1)
bit_{length_1}	length of bit 1, µs
bit_{length_2}	length of bit 2, µs
bit_{length_n}	length of bit *n*, µs
a	High level average.
b	Low level average.
c	50 % modulation level.

Figure 11 — Bit length measurement — FDX-B

a) Check that the constant magnetic field nulling procedure (7.6.3) has been carried out.

b) Set the waveform generator to 134,2 kHz.

c) Set the antenna current to obtain the minimal activating magnetic field strength.

d) Record the voltage pattern measured on the CN with the oscilloscope over 128 consecutive bits.

e) Process the data stream to extract each single bit length, bit_{length_n}.

f) Calculate the average bit length, bit_{length}, and bit stability, $bit_{stability}$, expressed in microseconds (µs) at the corresponding magnetic field strength.

g) Create a result table in accordance with Table 4 as well as a graphical presentation of the results.

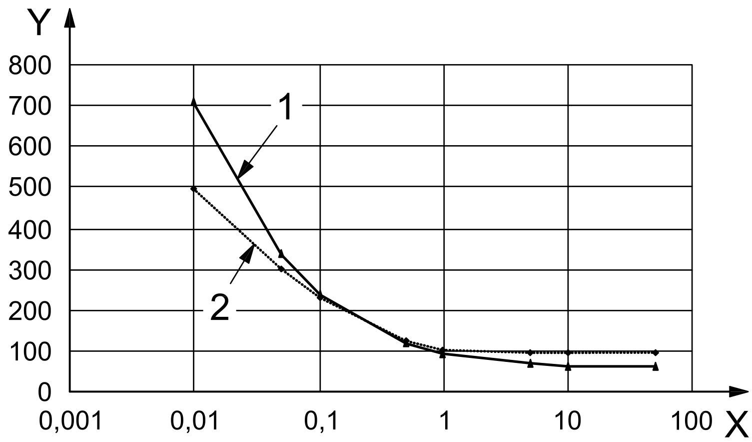
Table 4 — Bit length stability measurement results — FDX-B

Magnetic field strength A/m	bit_{length} µs	$bit_{stability}$
Minimal activating value	X	Y
…	…	…
50	R	S

h) Increase the magnetic field strength by five measuring points per decade and repeat the measurement until the table is completed.

i) Record the following for each measurement:

1)	Test type	bit length stability
2)	Waveform generator frequency	in kilohertz
3)	Identification code	
4)	Magnetic field value	in amperes per metre
5)	Single bit length, bit_{length_n}	in microseconds
6)	Average bit length, bit_{length}	in microseconds
7)	Bit stability	in microseconds
8)	Results table	as per Table 4
9)	Graphic representation of results	similar to Figure 12
10)	Ambient temperature	in degrees Celsius
11)	Ambient humidity (relative value)	as a percentage



Key

X magnetic field strength, A/m

Y bit stability ($bit_{stability}$), µs

1 TUT 1

2 TUT 2

Figure 12 — Bit length stability vs. magnetic field strength — FDX-B

7.6.9 Frequency stability in HDX mode

The purpose of this test is to determine the frequency stability of the bit representing frequencies. This value is related to the deviation of the frequency representing the time needed to transmit 1 bit of information. The value does not depend on the magnetic field strength and therefore shall be measured at the minimal activating field strength value and, if needed for verification, at a number of additional magnetic field strength values. It is necessary that the oscilloscope data be processed by the PC. The bit length time is measured based on the duration of the 16 cycles of the corresponding bit frequency (see Figure 13). The bit frequency value and its related stability are defined over the 94 bits from the rising edge of the start byte to the falling edge of the end byte [step c) of the following procedure]. Measure both return frequencies and compare them with the standard using Equations (7) and (8):

$$F_1 = \frac{\sum_{\text{bit } n=1}^{\text{bit } 94} \frac{\sum_{\text{cycle } m=1}^{\text{cycle } 16} F_{1_m}}{16}}{n_{F_1}} \tag{7}$$

where

F_1 is the average frequency of logical “1” bits, in hertz;

F_{1_m} is the frequency of one cycle of a logical “1” bit, in hertz;

n_{F_1} is the number of logical “1” bits.

$$F_0 = \frac{\sum_{\text{bit } n=1}^{\text{bit } 94} \frac{\sum_{\text{cycle } m=1}^{\text{cycle } 16} F_{0_m}}{16}}{n_{F_0}} \tag{8}$$

where

F_0 is the average frequency of logical “0” bits, in hertz;

F_{0_m} is the frequency of one cycle of a logical “0” bit, in hertz;

n_{F_0} is the number of logical “0” bits.

Check whether each bit consists of 16 HF periods using Equations (9) and (10):

$$F_{1\_\text{stability}} = 3\sqrt{\frac{\sum_{\text{bit } n=1}^{\text{bit}94} \left(\frac{\sum_{\text{cycle } m=1}^{\text{cycle}16} F_{1_m}}{16} - F_1 \right)^2}{n_{F_1} - 1}} \tag{9}$$

where

$F_{1\_\text{stability}}$ is the frequency stability of logical “1” bits, in kilohertz;

F_1 is the average frequency of logical “1” bits, in kilohertz;

F_{1_m} is the frequency of one cycle of a logical “1” bit, in kilohertz;

n_{F_1} is the number of logical “1” bits.

$$F_{0\_\text{stability}} = 3\sqrt{\frac{\sum_{\text{bit}\,n=1}^{\text{bit}94}\left(\frac{\sum_{\text{cycle}\,m=1}^{\text{cycle}16} F_{0_m}}{16} - F_0\right)^2}{n_{F_0} - 1}} \quad (10)$$

where

$F_{0\_\text{stability}}$ is the frequency stability of logical “0” bits, in kilohertz;

F_0 is the average frequency of logical “0” bits, in kilohertz;

F_{0_m} is the frequency of one cycle of a logical “0” bit, in kilohertz;

n_{F_0} is the number of logical “0” bits.

Value in number of clock frequency cycles

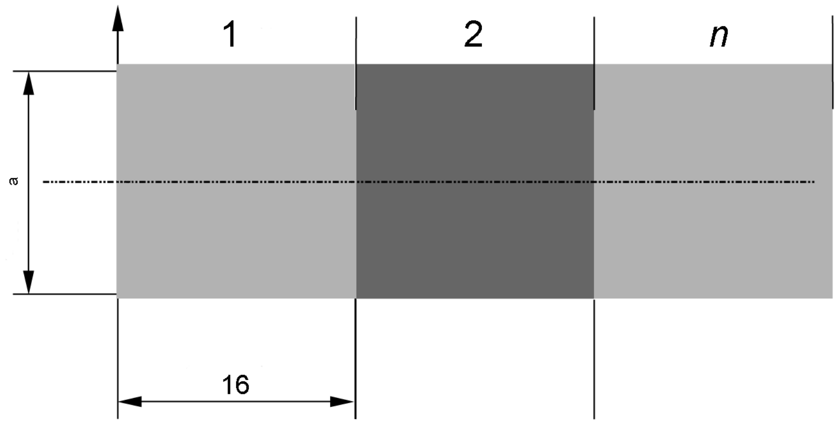


Figure 13 — Bit length measurement — HDX

a) Set the waveform generator to 134,2 kHz.

b) Set the antenna current to obtain the minimal activating magnetic field strength.

c) Record the voltage pattern measured on the HSC with the oscilloscope over 94 consecutive bits.

d) Process the data stream to extract each single bit length, $\text{bit}_{\text{length}\_n}$, from the measured frequency values.

e) Calculate the average frequency stability of each bit value.

f) Create a result table in accordance with Table 5.

Table 5 — Bit length stability measurement results — HDX

Magnetic field strength	F_1	$F_{1\_\text{stability}}$	F_0	$F_{0\_\text{stability}}$
A/m	kHz			
Minimal activating value	X	Y	X	Y
…	…	…	…	…
50	R	S	R	S

g) Optionally for HDX, the magnetic field strength may be increased by five measuring points per decade and the measurement repeated until the complete table is completed.

h) Record the following for each measurement:

1)	Test type	bit frequency stability
2)	Waveform generator frequency	in kilohertz
3)	Identification code:	
4)	Magnetic field value	in amperes per metre
5)	Single bit frequency, high	in kilohertz
6)	Single bit frequency, low	in kilohertz
7)	Average bit frequency, high	in kilohertz
8)	Average bit frequency, low	in kilohertz
9)	Frequency stability, high	in kilohertz
10)	Frequency stability, low	in kilohertz
11)	Results table	as per Table 5
12)	Ambient temperature	in degrees Celsius
13)	Ambient humidity (relative value)	as a percentage

Annex A
(normative)

Test application form

This form is also available on the RA web site: http://www.icar.org/.

RA approval date:			Date:
Company Name:		**Address:**	
Test: Transponders used for conformance test ☐		Combined with transponder conformance test ☐	
Device type:	Injectable transponder ☐		Tag attachment ☐
	Electronic ear tag ☐		Bolus ☐
			Other ☐
Device name/model:		**RA product code:**	
Technology:		HDX ☐	FDX-B ☐
Physical characteristics:			
Length:	Diameter:	Mass:	Colour:
Packaging material:			
Primary transponder packaging:			
Secondary transponder packaging:			
Photograph of device:			
The undersigned agrees to abide by the provisions of ISO 24631-3.			
Date:	**Name:**		**Position:**

Annex B
(informative)

Current source transmitter

A current source transmitter as shown in Figure B.1 can be used to avoid the detuning problems described in 7.2.7. With a self-inductance of 33 µH and a proposed R_s (surface resistance) of 4,7 Ω, the Q factor of this coil is 6. The dissipated power in the HTA is dependent on the current through the coils and has a value between 4,7 µW and 4,7 W.

The voltage on the 33 µH HTA coil has a value between 28 mV and 28 V. A series capacitor of 42 nF will reduce the imaginary component and reduce the impedance to 4,7 Ω, thereby reducing the transmitter voltage to a value between 4,7 mV and 4,7 V.

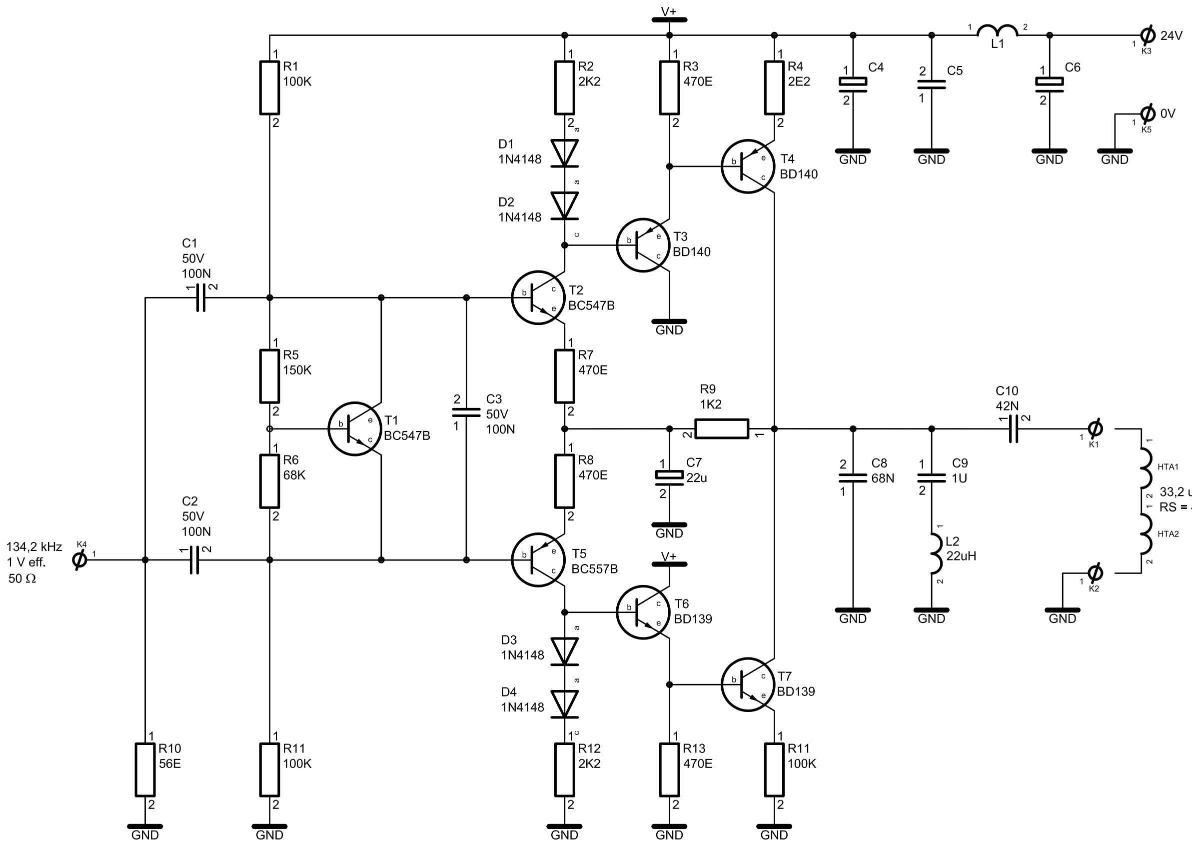


Figure B.1 — Current source transmitter

Bibliography

[1] *International agreement of recording practices*. ICAR Guidelines approved by the General Assembly held in Kuopio, Finland on 9 June 2006

[2] ISO/IEC 17000, *Conformity assessment — Vocabulary and general principles*

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