INTERNATIONAL STANDARD

ISO/IEC 15693-2

Third edition
2019-04

Cards and security devices for personal identification — Contactless vicinity objects —

Part 2: Air interface and initialization

Cartes et dispositifs de sécurité pour l'identification personnelle — Objets sans contact de voisinage —

Partie 2: Interface et initialisation dans l'air

Reference number
ISO/IEC 15693-2:2019(E)

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Joint Technical Committee ISO/IEC JTC1, *Information technology*, Subcommittee SC 17, *Cards and security devices for personal identification*.

This third edition cancels and replaces the second edition (ISO/IEC 15693-2:2006), which has been technically revised.

The main changes compared to the previous edition are as follows:

— fast response data rates in 8.4.3 and Annex B have been added.

A list of all parts in the ISO/IEC 15693 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

ISO/IEC 15693 (all parts) is one of a series of International Standards defining the parameters for identification cards as defined in ISO/IEC 7810 and the use of such cards for international interchange.

This document defines the electrical characteristics of the contactless interface between a vicinity card and a vicinity coupling device. The interface includes power and bi-directional communications.

Contactless card standards cover a variety of types as embodied in ISO/IEC 10536 (close-coupled cards), ISO/IEC 14443 (proximity cards) and ISO/IEC 15693 (vicinity cards). These are intended for operation when very near, nearby and at a longer distance from associated coupling devices, respectively.

Cards and security devices for personal identification — Contactless vicinity objects —

Part 2:
Air interface and initialization

1 Scope

This document specifies the nature and characteristics of the fields to be provided for power and bi-directional communications between vicinity coupling devices (VCDs) and vicinity cards (VICCs).

This document is intended to be used in conjunction with other parts of the ISO/IEC 15693 series.

This document does not preclude the incorporation of other standard technologies on the card as described in Annex A.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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/IEC 10373-7[1)], *Cards and security devices for personal identification — Test methods — Part 7: Contactless vicinity objects*

ISO/IEC 15693-1, *Cards and security devices for personal identification — Contactless vicinity objects — Part 1: Physical characteristics*

ISO/IEC 15693-3, *Cards and security devices for personal identification — Contactless vicinity objects — Part 3: Anticollision and transmission protocol*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 15693-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
modulation index
index equal to $[a-b]/[a+b]$ where a and b are the peak and minimum signal amplitudes, respectively

Note 1 to entry: The value of the index may be expressed as a percentage.

3.2
subcarrier
signal of frequency f_s used to modulate the carrier of frequency f_c

1) Under preparation.

3.3
byte
string that consists of 8 bits of data designated b1 to b8, from the most significant bit (MSB,b8) to the least significant bit (LSB,b1)

4 Symbols and abbreviated terms

4.1 Abbreviated terms

ASK	amplitude shift keying
EOF	end of frame
LSB	least significant bit
MSB	most significant bit
PPM	pulse position modulation
RF	radio frequency
SOF	start of frame
VCD	vicinity coupling device
VICC	vicinity integrated circuit card

4.2 Symbols

a	carrier amplitude without modulation
b	carrier amplitude when modulated
f_c	frequency of the operating field (carrier frequency)
f_s	frequency of the subcarrier
H_max	maximum operating field
H_min	minimum operating field

5 Initial dialogue for vicinity cards

The dialogue between the VCD and the VICC (one or more VICCs may be present at the same time) is conducted through the following consecutive operations:

— activation of the VICC by the RF operating field of the VCD;

— VICC waits silently for a command from the VCD;

— transmission of a command by the VCD;

— transmission of a response by the VICC.

These operations use the RF power transfer and communication signal interface specified in the following clauses and shall be performed according to the protocol defined in ISO/IEC 15693-3.

6 Power transfer

6.1 General

Power transfer to the VICC is accomplished by radio frequency via coupling antennas in the VCD and in the VICC. The RF operating field that supplies power to the VICC from the VCD is modulated for communication from the VCD to the VICC, as described in Clause 7.

6.2 Frequency

The frequency f_c of the RF operating field is 13,56 MHz ± 7 kHz.

6.3 Operating field

A VICC shall operate as intended continuously between H_{min} and H_{max}.

The minimum operating field is H_{min} and has a value of 150 mA/m rms.

The maximum operating field is H_{max} and has a value of 5 A/m rms.

A VCD shall generate a field of at least H_{min} and not exceeding H_{max} at the manufacturer's specified positions (operating volume).

In addition, the VCD shall be capable of powering any single reference VICC (defined in the test methods) at the manufacturer's specified positions (within the operating volume).

The VCD shall not generate a field higher than the value specified in ISO/IEC 15693-1 (alternating magnetic field) in any possible VICC position.

Test methods for determining the VCD operating field are defined in ISO/IEC 10373-7.

7 Communications signal interface VCD to VICC

7.1 General

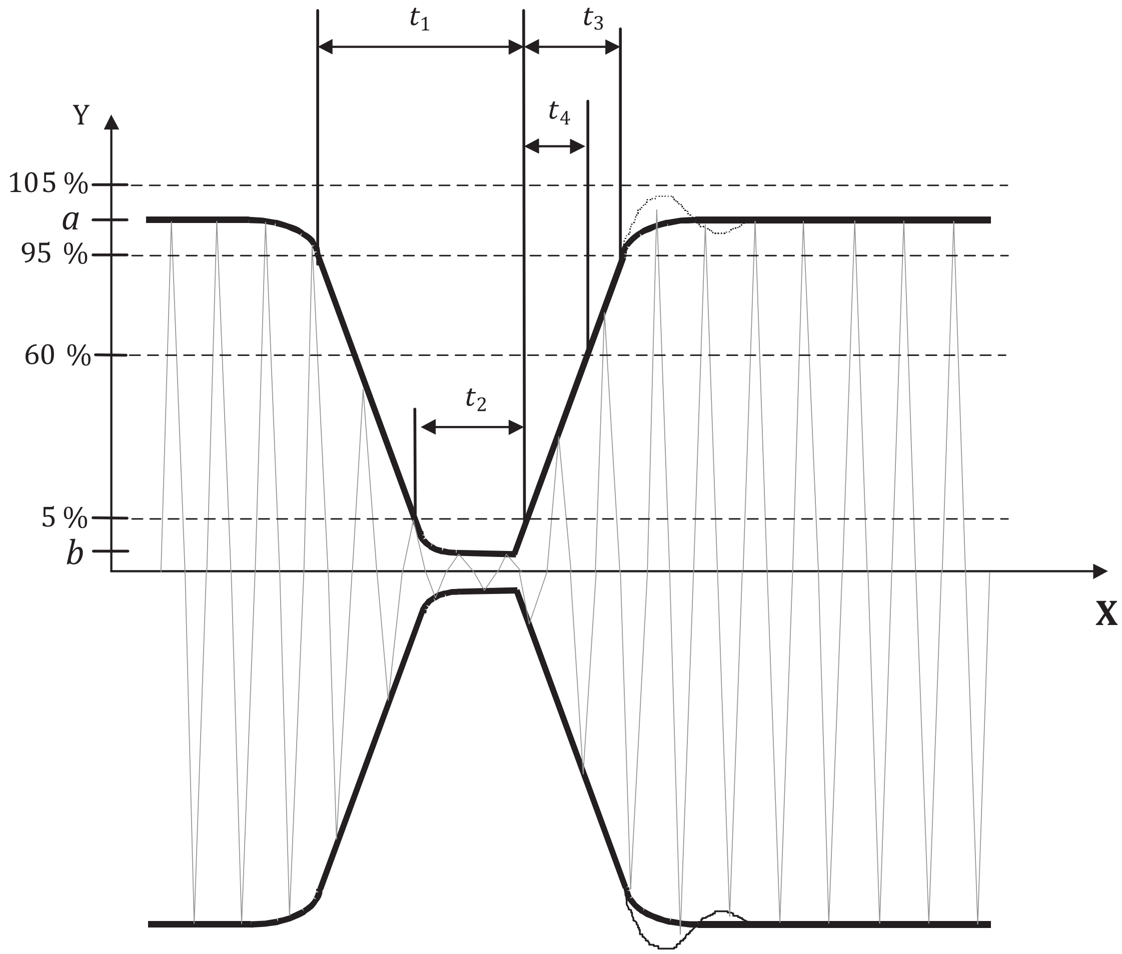
For some parameters several modes have been defined in order to meet different international radio regulations and different application requirements.

From the modes specified any data coding can be combined with any modulation.

7.2 Modulation

Communications between the VCD and the VICC take place using the modulation principle of ASK. Two modulation indexes are used, 10 % and 100 %. The VICC shall decode both. The VCD determines which index is used.

Depending on the choice made by the VCD, a "pause" will be created as described in Figure 1 and Figure 2.



Key

X time, in seconds

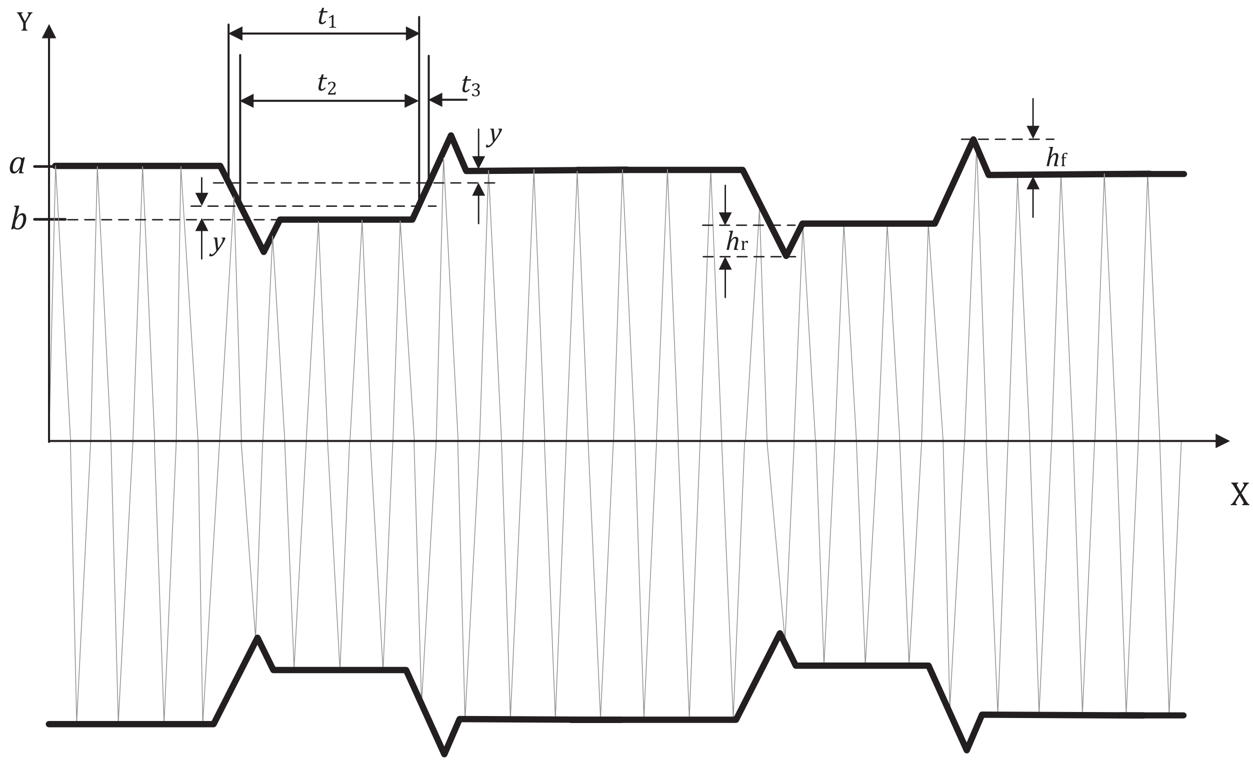
Y carrier amplitude

Figure 1 — Modulation of the carrier for 100 % ASK

The VCD shall generate the "pause" with timing parameters defined in Table 1.

Table 1 — VCD transmission: "pause" timing parameters for 100 % ASK

Parameter	Minimum	Maximum
t_1	6,0 µs	9,44 µs
t_2	2,1 µs	t_1
t_3	0 µs	4,5 µs
t_4	0 µs	0,8 µs



Key

X time, in seconds

Y carrier amplitude

Figure 2 — Modulation of the carrier for 10 % ASK

The VCD shall generate the "pause" with timing and amplitude parameters defined in Table 2.

Table 2 — VCD transmission: "pause" timing parameters for 10 % ASK

Parameter	Condition	Minimum	Maximum
t_1	$y = 0{,}05 \times (a - b)$	6,0 µs	9,44 µs
t_2		3,0 µs	t_1
t_3		0 µs	4,5 µs
Modulation index		10 %	30 %
h_f, h_r		0	$0{,}1 \times (a - b)$

The VICC shall be operational for any value of modulation index between 10 % and 30 %.

The digital generation of the pause by the VCD, shown approximately in 7.3 and 7.4 as t_{pause}, shall not cause t_{1max} as defined in Figures 1 and 2 to be exceeded.

7.3 Data rate and data coding

7.3.1 General

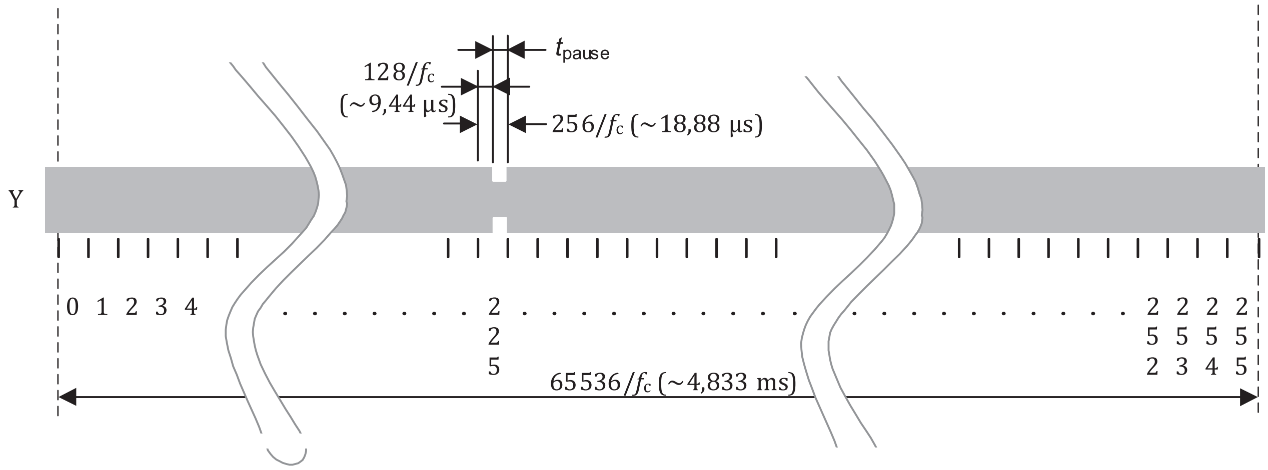
Data coding shall be implemented using pulse position modulation.

Two data coding modes shall be supported by the VICC. The selection shall be made by the VCD and indicated to the VICC within the SOF, as defined in 7.4.

7.3.2 Data coding mode: 1 out of 256

The value of one single byte shall be represented by the position of one pause. The position of the pause on 1 of 256 successive time periods of $256/f_c$ (~18,88 µs), determines the value of the byte. In this case the transmission of one byte takes ~4,833 ms and the resulting data rate is 1,66 kbits/s (f_c/8 192). The last byte of the frame shall be completely transmitted before the EOF is sent by the VCD.

Figure 3 illustrates this pulse position modulation technique.



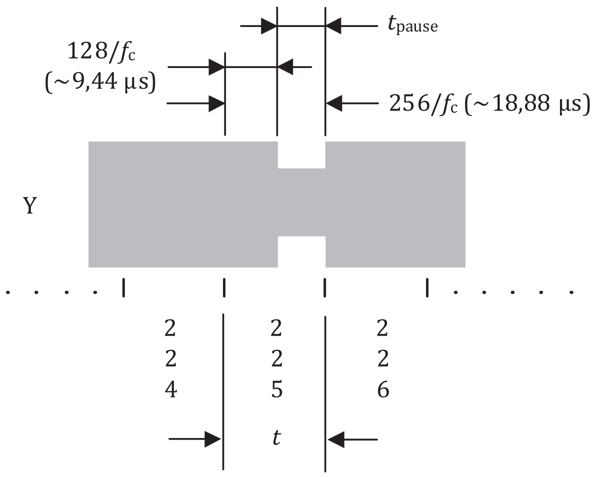
Key

Y pulse modulated carrier

Figure 3 — 1 out of 256 coding mode

In Figure 3 data 'E1' = (11100001)b = (225) is sent by the VCD to the VICC.

The pause shall occur during the second half of the position of the time period that determines the value, as shown in Figure 4.



Key

Y pulse modulated carrier

t time period one of 256

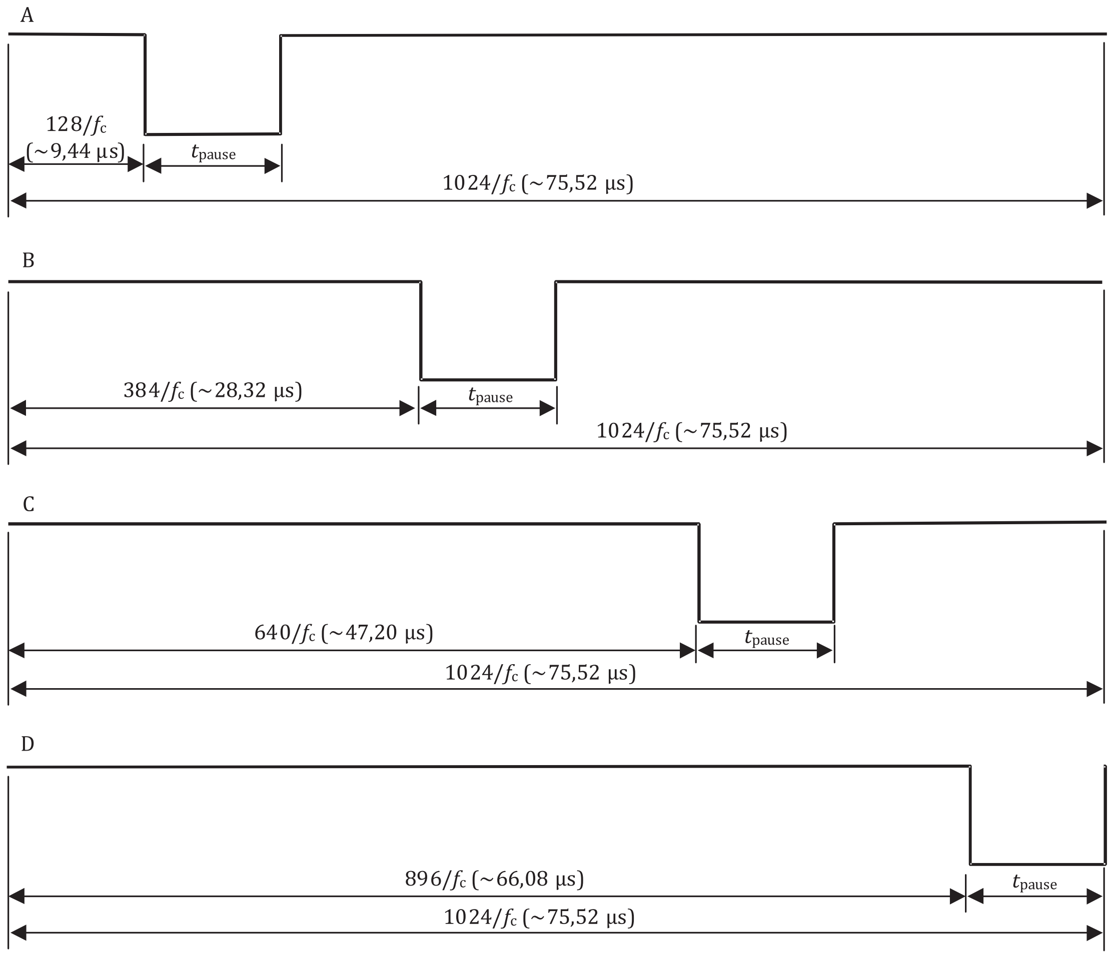
Figure 4 — Detail of one time period

7.3.3 Data coding mode: 1 out of 4

Pulse position modulation for 1 out of 4 mode shall be used, in this case the position determines two bits at a time. Four successive pairs of bits form a byte, where the least significant pair of bits is transmitted first.

The resulting data rate is 26,48 kbits/s (f_c/512).

Figure 5 illustrates the 1 out of 4 pulse position technique and coding.



Key

A pulse position for "00"

B pulse position for "01" (1 = LSB)

C pulse position for "10" (0 = LSB)

D pulse position for "11"

Figure 5 — 1 out of 4 coding mode

For example, Figure 6 shows the transmission of 'E1' = (11100001)b = 225 by the VCD.

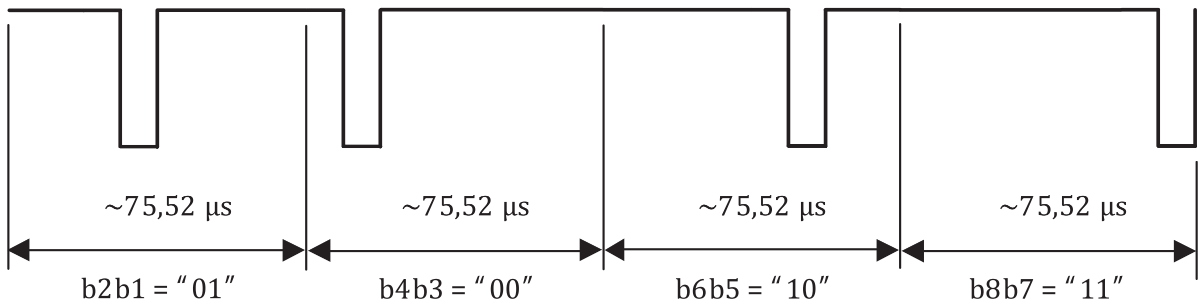


Figure 6 — 1 out of 4 coding example

7.4 VCD to VICC frames

7.4.1 General

Framing has been chosen for ease of synchronization and independence of protocol.

Frames shall be delimited by an SOF and an EOF and are implemented using code violation. Unused options are reserved for future use by ISO/IEC.

The VICC shall be ready to receive a frame from the VCD within 300 µs after having sent a frame to the VCD.

The VICC shall be ready to receive a frame within 1 ms of activation by the powering field.

7.4.2 SOF to select 1 out of 256 code

The SOF sequence described in Figure 7 selects the 1 out of 256 data coding mode.

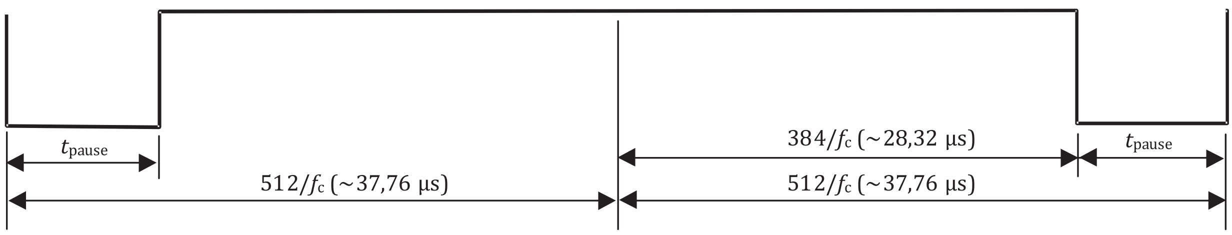


Figure 7 — Start of frame of the 1 out of 256 mode

7.4.3 SOF to select 1 out of 4 code

The SOF sequence described in Figure 8 selects the 1 out of 4 data coding mode.

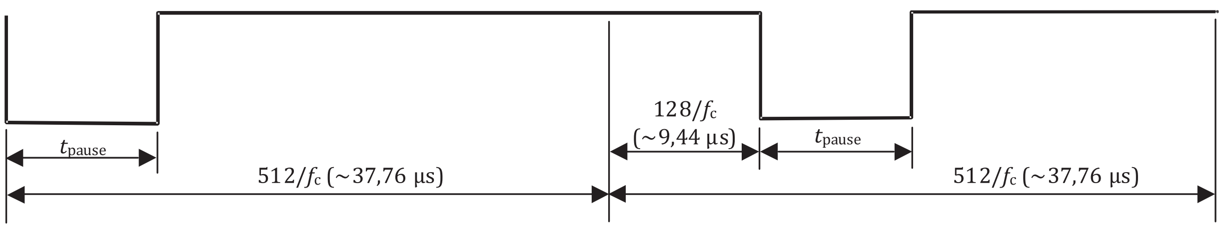


Figure 8 — Start of frame of the 1 out of 4 mode

7.4.4 EOF for either data coding mode

The EOF sequence for either coding mode is described in Figure 9.

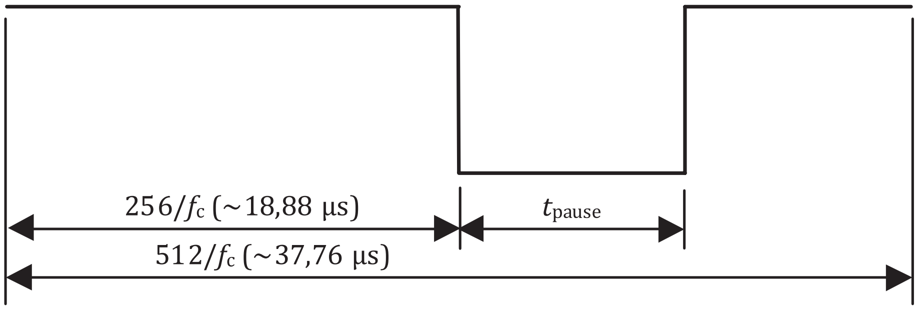


Figure 9 — End of frame for either mode

8 Communications signal interface VICC to VCD

8.1 General

For some parameters several modes have been defined in order to allow for use in different noise environments and application requirements. Higher response data rates, especially the fast response data rates may be more sensitive to the noise environment and may result in reduced operating range.

8.2 Load modulation

The VICC shall be capable of communication to the VCD via an inductive coupling area whereby the carrier is loaded to generate a subcarrier with frequency f_S. The subcarrier shall be generated by switching a load in the VICC.

The load modulation amplitude shall be at least 10 mV when measured according to the test methods for VICC load modulation defined in ISO/IEC 10373-7.

8.3 Subcarrier

For low or high data rates one or two subcarriers may be used as selected by the VCD using the first bit in the protocol header as defined in ISO/IEC 15693-3. The VICC shall support both modes.

For fast response data rates only one subcarrier shall be used.

When one subcarrier is used, the frequency f_{S1} of the subcarrier load modulation shall be $f_C/32$ (423,75 kHz).

When two subcarriers are used, the frequency f_{S1} shall be $f_C/32$ (423,75 kHz), and the frequency f_{S2} shall be $f_C/28$ (484,28 kHz).

If two subcarriers are present, there shall be a continuous phase relationship between them.

8.4 Data rates

8.4.1 General

In addition to the low and high data rates defined here, fast response data rates have been introduced as defined in Annex B.

8.4.2 Low and high data rates

A low or high data rate may be used. The selection of the data rate shall be made by the VCD using the second bit in the protocol header as defined in ISO/IEC 15693-3. The VICC shall support the data rates shown in Table 3.

Table 3 — Data rates

Data rate	Single subcarrier	Dual subcarrier
Low	6,62 kbits/s (f_c/2048)	6,67 kbits/s (f_c/2032)
High	26,48 kbits/s (f_c/512)	26,69 kbits/s (f_c/508)

8.4.3 Fast response data rates

Fast response data rates as defined in Annex B shall only be used for some optional commands as defined in ISO/IEC 15693-3. The fast response data rate X2, X4 and X8 shall only be used with a single subcarrier. The selection of the data rate shall be made by the VCD using the 2nd and 8th bits in the protocol header as defined in ISO/IEC 15693-3. The VICC supporting these particular optional commands shall support the data rates shown in Table 4.

Table 4 — Fast response data rates

Fast data rate	Single subcarrier	Dual subcarrier
X2	52,97 kbits/s (f_c/256)	Not supported
X4	105,94 kbits/s (f_c/128)	Not supported
X8	211,88 kbits/s (f_c/64)	Not supported

8.5 Bit representation and coding

8.5.1 General

Data shall be encoded using Manchester coding according to the following schemes. All timings shown refer to the high data rate from the VICC to the VCD. For the low data rate the same subcarrier frequency or frequencies are used, in this case the number of pulses and the timing shall be multiplied by 4.

For a fast response data rate X2, X4 and X8, the same single subcarrier frequency shall be used. The number of pulses and timings are divided by 2 (X2 data rate), 4 (X4 data rate) and 8 (X8 data rate) respectively (see Annex B).

8.5.2 Bit coding when using one subcarrier

A logic 0 starts with 8 pulses of f_c/32 (~423,75 kHz) followed by an unmodulated time of 256/f_c (~18,88 µs), see Figure 10.

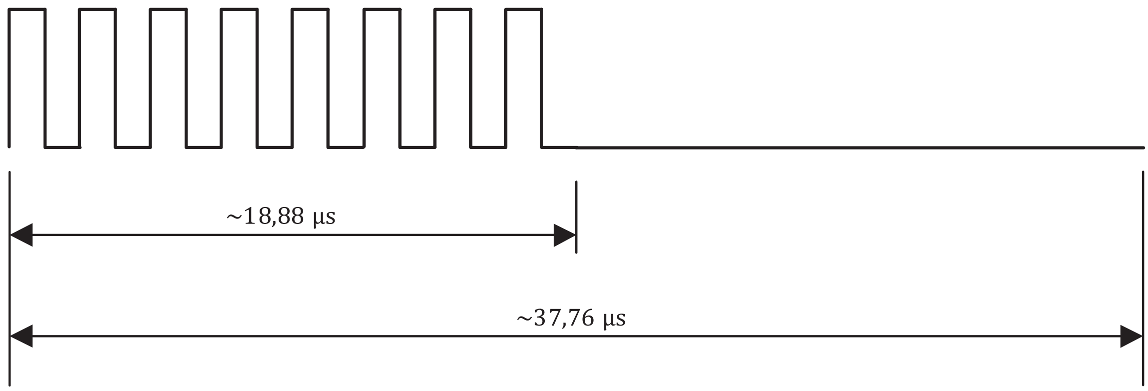


Figure 10 — Logic 0 when using one subcarrier

A logic 1 starts with an unmodulated time of $256/f_c$ (~18,88 µs) followed by 8 pulses of $f_c/32$ (~423,75 kHz), see Figure 11.

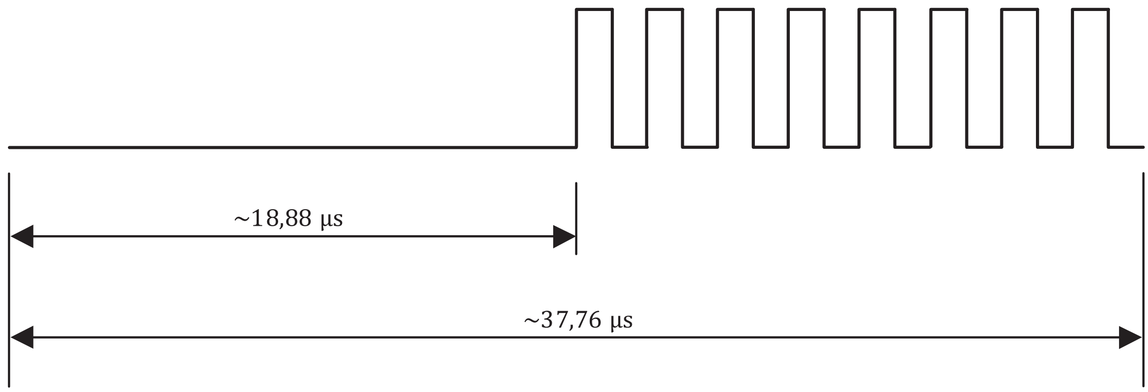


Figure 11 — Logic 1 when using one subcarrier

8.5.3 Bit coding when using two subcarriers

A logic 0 starts with 8 pulses of $f_c/32$ (~423,75 kHz) followed by 9 pulses of $f_c/28$ (~484,28 kHz), see Figure 12.

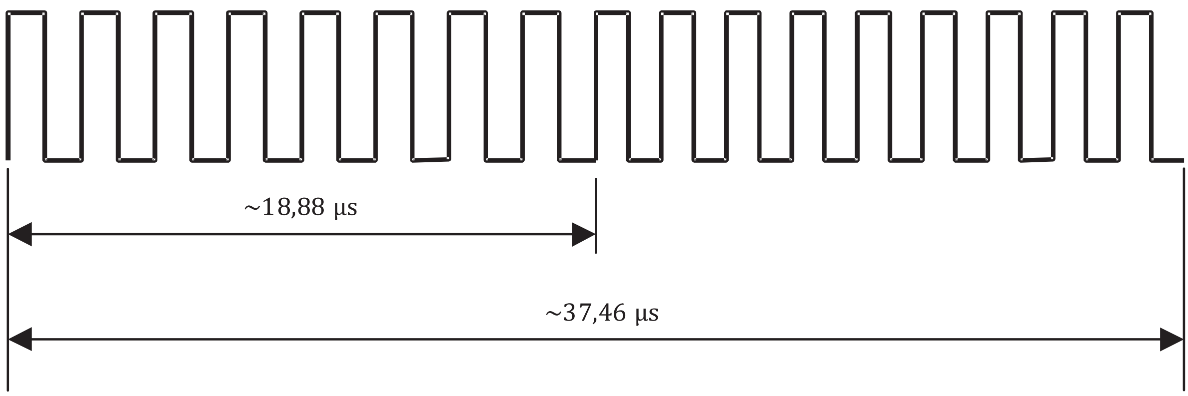


Figure 12 — Logic 0 when using two subcarriers

A logic 1 starts with 9 pulses of $f_c/28$ (~484,28 kHz) followed by 8 pulses of $f_c/32$ (~423,75 kHz), see Figure 13.

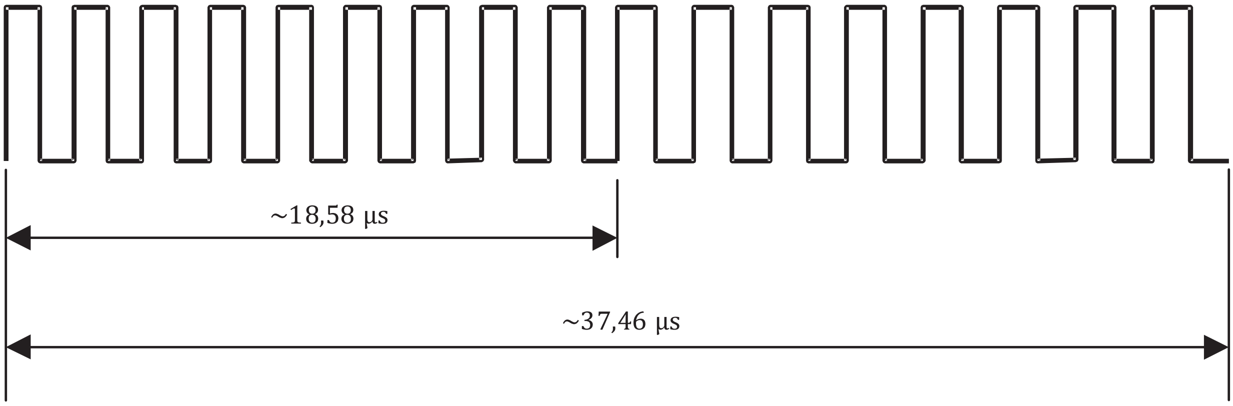


Figure 13 — Logic 1 when using two subcarriers

8.6 VICC to VCD frames

8.6.1 General

Framing has been chosen for ease of synchronization and independence of protocol.

Frames are delimited by an SOF and an EOF and are implemented using code violation. Unused options are reserved for future use by the ISO/IEC.

All timings shown below refer to the high data rate from the VICC to the VCD.

For the low data rate the same subcarrier frequency or frequencies are used, in this case the number of pulses and the timing shall be multiplied by 4.

The VCD shall be ready to receive a frame from the VICC within 300 µs after having sent a frame to the VICC.

8.6.2 SOF when using one subcarrier

The SOF comprises 3 parts:

— an unmodulated time of $768/f_c$ (~56,64 µs);

— 24 pulses of $f_c/32$ (~423,75 kHz);

— a logic 1 which starts with an unmodulated time of $256/f_c$ (~18,88 µs), followed by 8 pulses of $f_c/32$ (~423,75 kHz).

The SOF for one subcarrier is illustrated in Figure 14.

Figure 14 — Start of frame when using one subcarrier

8.6.3 SOF when using two subcarriers

The SOF comprises 3 parts:

— 27 pulses of $f_c/28$ (~484,28 kHz);

— 24 pulses of $f_c/32$ (~423,75 kHz);

— a logic 1 which starts with 9 pulses of $f_c/28$ (~484,28 kHz) followed by 8 pulses of $f_c/32$ (~423,75 kHz).

The SOF for 2 subcarriers is illustrated in Figure 15.

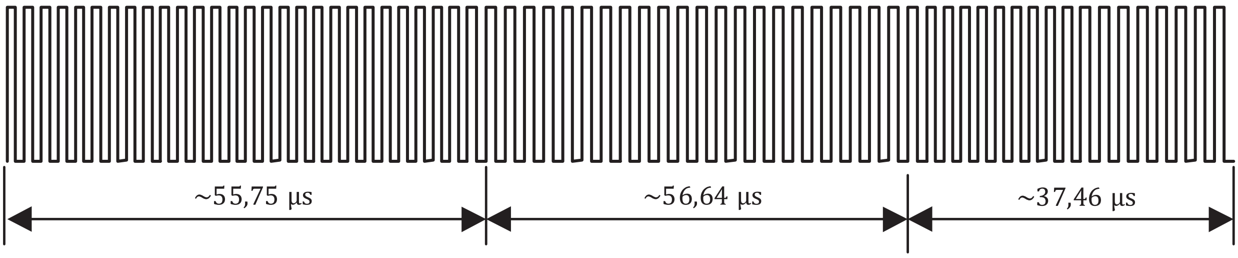


Figure 15 — Start of frame when using two subcarriers

8.6.4 EOF when using one subcarrier

The EOF comprises 3 parts:

— a logic 0 which starts with 8 pulses of $f_c/32$ (~423,75 kHz), followed by an unmodulated time of $256/f_c$ (~18,88 µs);

— 24 pulses of $f_c/32$ (~423,75 kHz);

— an unmodulated time of $768/f_c$ (~56,64 µs).

The EOF for 1 subcarrier is illustrated in Figure 16.

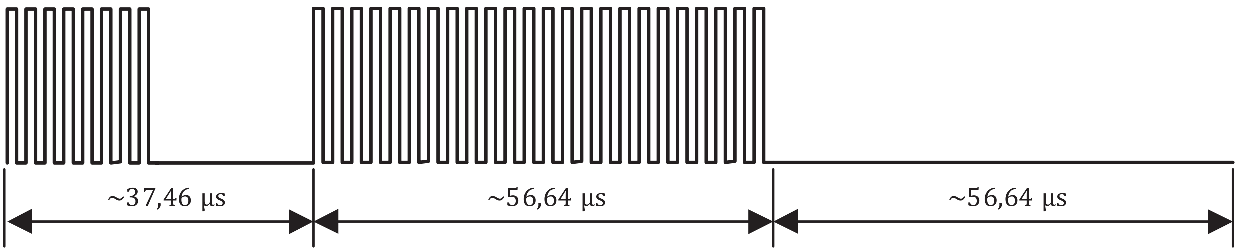


Figure 16 — End of frame when using one subcarrier

8.6.5 EOF when using two subcarriers

The EOF comprises 3 parts:

— a logic 0 which starts with 8 pulses of $f_c/32$ (~423,75 kHz) followed by 9 pulses of $f_c/28$ (~484,28 kHz);

— 24 pulses of $f_c/32$ (~423,75 kHz);

— 27 pulses of $f_c/28$ (~484,28 kHz).

The EOF for 2 subcarriers is illustrated in Figure 17.

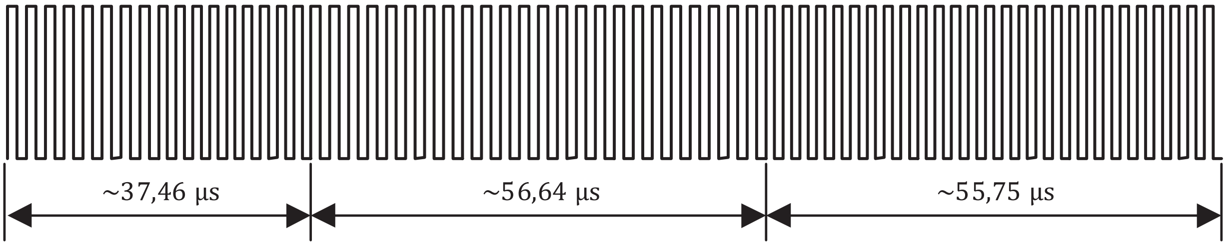


Figure 17 — End of frame when using two subcarriers

Annex A
(informative)

Standards compatibility

This document does not preclude the addition of other existing card standards on the VICC, such as those listed as follows:

— ISO/IEC 7811 (all parts), on recording technique;

— ISO/IEC 7812 (all parts), on Identification of issuers;

— ISO/IEC 7813, on financial transaction cards;

— ISO/IEC 7816 (all parts), on integrated circuit cards;

— ISO/IEC 10536 (all parts), on contactless integrated circuit(s) cards;

— ISO/IEC 14443 (all parts), on contactless proximity objects.

Annex B
(normative)

Bit coding and frames for a fast response data

B.1 Bit representation and coding

B.1.1 General

Fast response data shall be encoded using Manchester coding according to the following schemes.

B.1.2 Bit coding for X2

A logic 0 starts with 4 pulses of $f_c/32$ (~423,75 kHz) followed by an unmodulated time of $128/f_c$ (~9,44 µs), see Figure B.1.

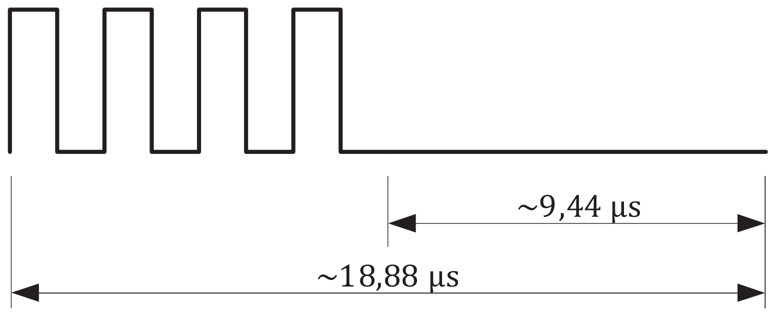


Figure B.1 — Logic 0 for X2

A logic 1 starts with an unmodulated time of $128/f_c$ (~9,44 µs) followed by 4 pulses of $f_c/32$ (~423,75 kHz), see Figure B.2.

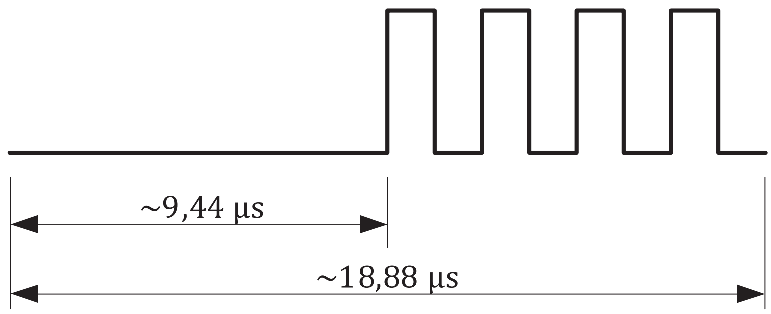


Figure B.2 — Logic 1 for X2

B.1.3 Bit coding for X4

A logic 0 starts with 2 pulses of $f_c/32$ (~423,75 kHz) followed by an unmodulated time of $64/f_c$ (~4,72 µs), see Figure B.3.

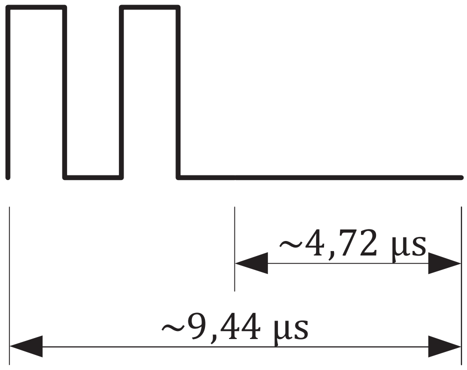


Figure B.3 — Logic 0 for X4

A logic 1 starts with an unmodulated time of $64/f_c$ (~4,72 µs) followed by 2 pulses of $f_c/32$ (~423,75 kHz), see Figure B.4.

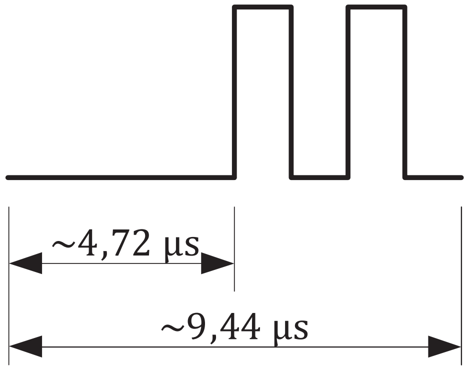


Figure B.4 — Logic 1 for X4

B.1.4 Bi t coding for X8

A logic 0 starts with 1 pulse of $f_c/32$ (~423,75 kHz) followed by an unmodulated time of $32/f_c$ (~2,36 µs), see Figure B.5.

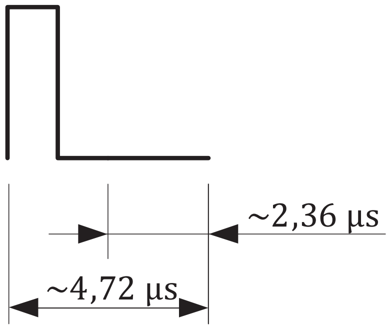


Figure B.5 — Logic 0 for X8

A logic 1 starts with an unmodulated time of $32/f_c$ (~2,36 µs) followed by 1 pulse of $f_c/32$ (~423,75 kHz), see Figure B.6.

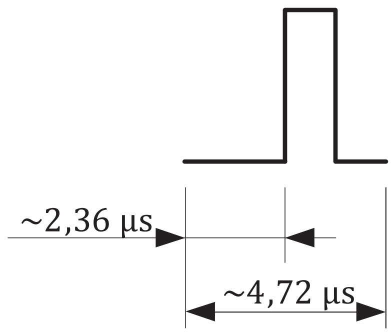


Figure B.6 — Logic 1 for X8

B.2 VICC to VCD frames

B.2.1 General

Frames of a fast response data are delimited by an SOF and an EOF.

The VCD shall be ready to receive a frame from the VICC within 300 µs after having sent a frame to the VICC.

B.2.2 SOF and EOF for X2

The SOF comprises 3 parts:

— an unmodulated time of $384/f_c$ (~28,32 µs);

— 12 pulses of $f_c/32$ (~423,75 kHz);

— a logic 1 which starts with an unmodulated time of $128/f_c$ (~9,44 µs), followed by 4 pulses of $f_c/32$ (~423,75 kHz).

The SOF for a fast response data of X2 is illustrated in Figure B.7.

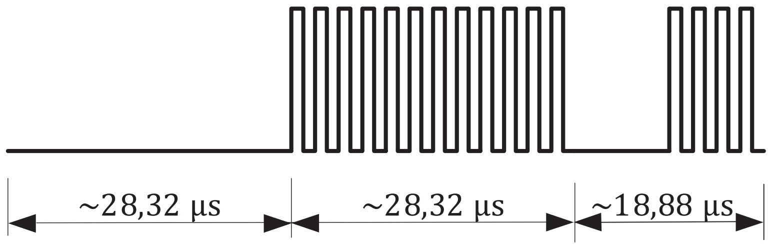


Figure B.7 — SOF for X2

The EOF comprises 3 parts:

— a logic 0 which starts with 4 pulses of $f_c/32$ (~423,75 kHz), followed by an unmodulated time of $128/f_c$ (~9,44 µs);

— 12 pulses of $f_c/32$ (~423,75 kHz);

— an unmodulated time of $384/f_c$ (~28,32 µs).

The EOF for a fast response data of X2 is illustrated in Figure B.8.

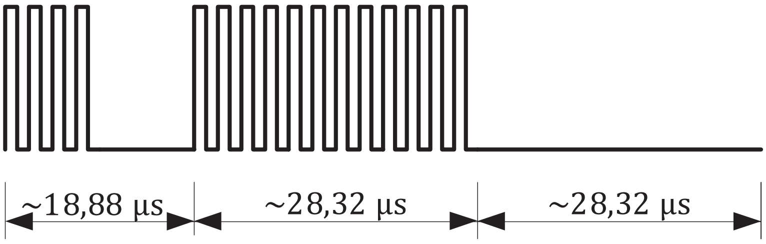


Figure B.8 — EOF for X2

B.2.3 SOF and EOF for X4

The SOF comprises 3 parts:

— an unmodulated time of 192/f_c (~14,16 µs);

— 6 pulses of f_c/32 (~423,75 kHz);

— a logic 1 which starts with an unmodulated time of 64/f_c (~4,72 µs), followed by 2 pulses of f_c/32 (~423,75 kHz).

The SOF for a fast response data of X4 is illustrated in Figure B.9.

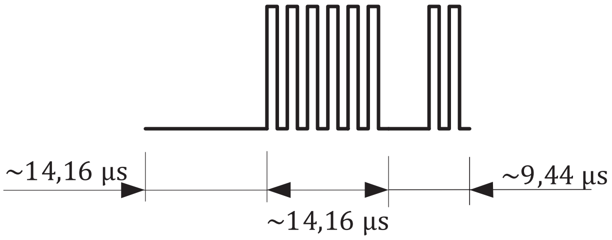


Figure B.9 — SOF for X4

The EOF comprises 3 parts:

— a logic 0 which starts with 2 pulses of f_c/32 (~423,75 kHz), followed by an unmodulated time of 64/f_c (~4,72 µs);

— 6 pulses of f_c/32 (~423,75 kHz);

— an unmodulated time of 192/f_c (~14,16 µs).

The EOF for a fast response data of X4 is illustrated in Figure B.10.

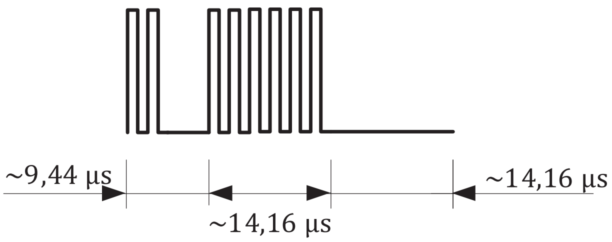


Figure B.10 — EOF for X4

B.2.4 SOF and EOF for X8

The SOF comprises 3 parts:

— an unmodulated time of $96/f_c$ (~7,08 µs);

— 3 pulses of $f_c/32$ (~423,75 kHz);

— a logic 1 which starts with an unmodulated time of $32/f_c$ (~2,36 µs), followed by 1 pulses of $f_c/32$ (~423,75 kHz).

The SOF for a fast response data of X8 is illustrated in Figure B.11.

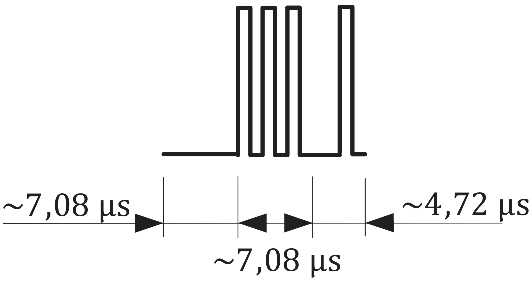


Figure B.11 — SOF for X8

The EOF comprises 3 parts:

— a logic 0 which starts with 1 pulses of $f_c/32$ (~423,75 kHz), followed by an unmodulated time of $32/f_c$ (~2,36 µs);

— 3 pulses of $f_c/32$ (~423,75 kHz);

— an unmodulated time of $96/f_c$ (~7,08 µs).

The EOF for a fast response data of X8 is illustrated in Figure B.12.

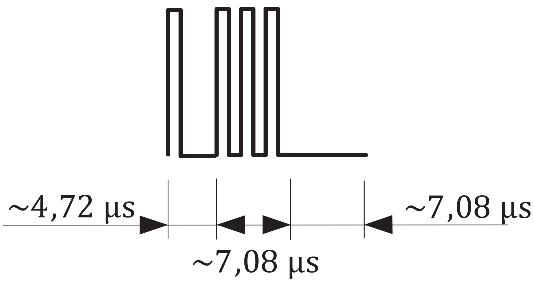


Figure B.12 — EOF for X8

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2) Under preparation.

ICS 35.240.15

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