INTERNATIONAL STANDARD

ISO/IEC 7816-3

Second edition
1997-12-15

Information technology — Identification cards — Integrated circuit(s) cards with contacts —

Part 3:
Electronic signals and transmission protocols

Technologies de l'information — Cartes d'identification — Cartes à circuit(s) intégré(s) à contacts —

Partie 3: Signaux électroniques et protocoles de transmission

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Contents

Page

Foreword ... iii
Introduction ... iv

1 Scope ... 1
2 Normative references ... 1
3 Terms and definitions ... 1
4 Electrical characteristics ... 2
4.1 General ... 2
4.2 Operating conditions ... 2
4.3 Voltage and current values ... 3
5 Card operating procedure ... 6
5.1 General overview ... 6
5.2 Activation ... 6
5.3 Information exchange ... 6
5.4 Deactivation ... 7
6 Answer-to-Reset ... 8
6.1 General configuration ... 8
6.2 Parameter T ... 8
6.3 Asynchronous character ... 9
6.4 Answer-to-Reset structure ... 10
6.5 Content of the global interface bytes ... 11
6.6 Modes of operation ... 13
7 Protocol and parameters selection ... 14
7.1 General ... 14
7.2 PPS protocol ... 14
7.3 Structure and content of PPS request and response ... 14
7.4 Successful PPS exchange ... 15
8 Protocol T=0, half-duplex transmission of asynchronous characters ... 15
8.1 Scope ... 15
8.2 Character level ... 15
8.3 Structure and processing of commands ... 15
9 Protocol T=1, half-duplex asynchronous transmission of blocks ... 17
9.1 Scope and principles ... 17
9.2 Terms and definitions ... 17
9.3 Character frame ... 18
9.4 Block frame ... 18
9.5 Protocol parameters ... 20
9.6 Character component operation at data link layer ... 21
9.7 Block component operation at data link layer ... 21

Annex A (informative) Scenarios for T=1 ... 24

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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.

In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1. 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.

International Standard ISO/IEC 7816-3 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 17, *Identification cards and related devices*.

This second edition cancels and replaces the first edition (ISO/IEC 7816-3:1989), which has been technically revised. It also incorporates Amendment 1:1992 and Amendment 2:1994.

ISO/IEC 7816 consists of the following parts, under the general title *Information technology — Identification cards — Integrated circuit(s) cards with contacts*:

— *Part 1: Physical characteristics*

— *Part 2: Dimensions and location of the contacts*

— *Part 3: Electronic signals and transmission protocols*

— *Part 4: Interindustry commands for interchange*

— *Part 5: Numbering system and registration procedure for application identifiers*

— *Part 6: Interindustry data elements*

— *Part 7: Interindustry commands for structured card query language*

Annex A of this part of ISO/IEC 7816 is for information only.

Introduction

ISO/IEC 7816 is a series of International Standards describing the parameters for integrated circuit(s) cards with contacts and the use of such cards for international interchange.

The integrated circuit(s) cards with contacts are identification cards intended for information exchange negotiated between the outside and the integrated circuit within the card. During each information exchange, the card delivers information (computation results, stored data) and/or modifies its content (data storage, event memorization).

During the preparation of this International Standard, information was gathered concerning relevant patents upon which application of this standard might depend. Relevant patents were identified in France and USA, the patent holder being Bull S.A. in each case. However, ISO cannot give authoritative or comprehensive information about the evidence, validity or scope of the patents or similar rights.

The patent holder has stated that licenses will be granted in appropriate terms to enable the application of this part of ISO/IEC 7816, provided that those who seek licenses agree to reciprocate.

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Information technology — Identification cards — Integrated circuit(s) cards with contacts —

Part 3:
Electronic signals and transmission protocols

1 Scope

This part of ISO/IEC 7816 specifies the power and signal structures, and information exchange between an integrated circuit(s) card and an interface device such as a terminal.

It also covers signal rates, voltage levels, current values, parity convention, operating procedure, transmission mechanisms and communication with the card.

It does not cover information and instruction content, such as identification of issuers and users, services and limits, security features, journaling and instruction definitions.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO/IEC 7816. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO/IEC 7816 are encouraged to investigate the possibility of applying the most recent editions of the standards listed below. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 1177:1985, *Information processing — Character structure for start/stop and synchronous character oriented transmission.*

ISO/IEC 3309:1993, *Information technology — Telecommunications and information exchange between systems — High-level data link control (HDLC) procedures — Frame structure.*

ISO/IEC 7810:1995, *Identification cards — Physical characteristics.*

ISO 7816-1:1987[1], *Identification cards — Integrated circuit(s) cards with contacts — Part 1: Physical characteristics.*

ISO 7816-2:1988[1], *Identification cards — Integrated circuit(s) cards with contacts — Part 2: Dimensions and location of the contacts.*

ISO/IEC 7816-4:1995, *Information technology — Identification cards — Integrated circuit(s) cards with contacts — Part 4: Interindustry commands for interchange.*

[1] Currently under revision.

3 Terms and definitions

The term "identification card" is defined in ISO/IEC 7810. For the purposes of this part of ISO/IEC 7816, the following definitions apply.

3.1 devices

3.1.1
interface device
terminal, communication device or machine to which the card is electrically connected during operation

3.1.2
operating card
card which can correctly carry out all its functions

3.2
etu (abbreviation for "elementary time unit")
nominal duration of a moment on contact I/O

3.3 resets

3.3.1
cold reset
first reset occurring after activation

3.3.2
warm reset
any reset which is not a cold reset

For the purposes of this part of ISO/IEC 7816, the following notations apply.

state H high state logic level

state L low state logic level

state Z mark or high state, as defined in ISO 1177

state A space or low state, as defined in ISO 1177

'XY' hexadecimal notation, equal to XY to the base 16

4 Electrical characteristics

4.1 General

4.1.1 Electrical circuits

Contact assignments are specified in ISO 7816-2, supporting at least the following electrical circuits.

GND	ground, reference voltage
VCC	power supply input
I/O	input or output for serial data
CLK	clock signal input
RST	reset signal input
VPP	programming power input, optional use by the card

4.1.2 Abbreviations

For the purposes of this clause, the following abbreviations apply.

C_{IN}	input capacitance
C_{OUT}	output capacitance
I_{CC}	current at VCC
I_{IH}	high level input current
I_{IL}	low level input current
I_{OH}	high level output current
I_{OL}	low level output current
I_{PP}	current at VPP
t_F	fall time, from 90 % to 10 % of signal amplitude
t_R	rise time, from 10 % to 90 % of signal amplitude
V_{CC}	voltage at VCC
V_{IH}	high level input voltage
V_{IL}	low level input voltage
V_{OH}	high level output voltage
V_{OL}	low level output voltage
V_{PP}	voltage at VPP

4.2 Operating conditions

4.2.1 Classes of operating conditions

This part of ISO/IEC 7816 defines two classes of operating conditions. Through contact VCC, the interface device shall provide to the card the following nominal supply voltage:

- 5 V under class A,
- 3 V under class B.

Consequently, cards and interface devices shall work either in class A only, or in class B only, or in class A and in class B, denoted as class AB later on.

Class A cards shall operate with class A and class AB interface devices. Class AB cards shall operate with class A, class B and class AB interface devices. Class B cards shall operate with class B and class AB interface devices; they shall be designed in such a way that they will not be damaged under class A operating conditions (by definition, a damaged card no longer operates as specified or contains corrupt data).

4.2.2 Selection of the operating class

Figure 1 shows the decisions to be made by an interface device in selecting the class of operating conditions to be applied to a card. Decisions shown are based upon information implicit in the interface device, except where the word "card" is present.

When available in the interface device, the first operating conditions to be applied to the card shall be class B.

Under class A operating conditions, a class B card shall not provide an Answer-to-Reset (see 6).

If the card does not provide an Answer-to-Reset, then the interface device shall deactivate the card; after a delay of at least 10 ms, the interface device shall apply the operating conditions of the next available class.

If the card provides an Answer-to-Reset without a class indicator (see 6.5.6), then the interface device shall apply or maintain class A operating conditions when available, or deactivate the card.

If the card provides an Answer-to-Reset with a class indicator, and the interface device is applying a class of operating conditions supported by the card, then normal operation may continue.

If the Answer-to-Reset does not indicate the current class of operating conditions, but another class supported by the interface device, then the interface device shall deactivate the card; after a delay of at least 10 ms, the interface device shall apply the operating conditions of that class.

NOTE — Some cards conforming to ISO/IEC 7816-3:1989 could be damaged when operating under class B conditions and should be used only in class A interface devices.

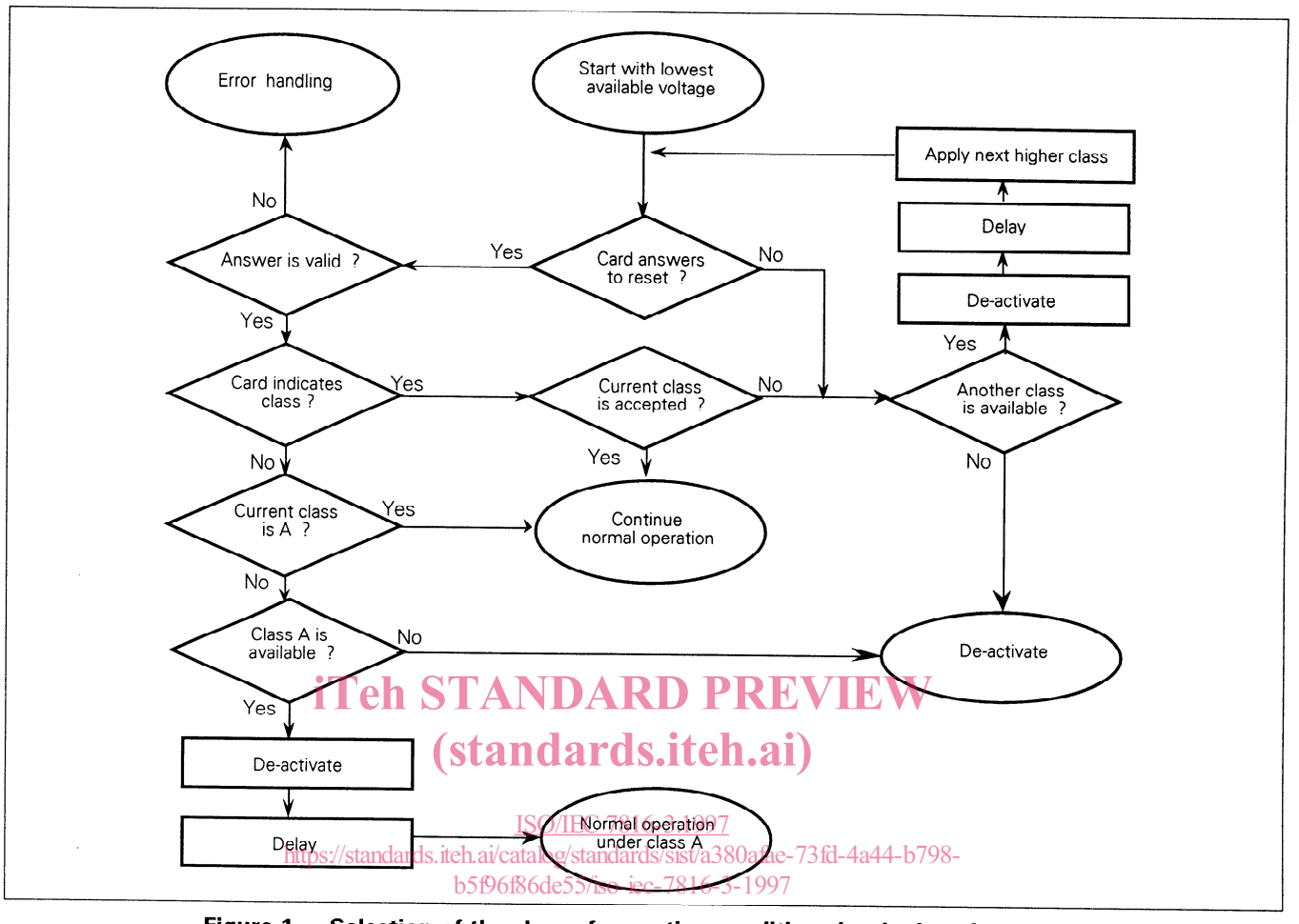

Figure 1 — Selection of the class of operating conditions by the interface device

4.3 Voltage and current values

4.3.1 Measurement conventions

All measurements are defined with respect to contact GND and in an ambient temperature range from 0° C to 50° C. All currents flowing into the card are considered positive. All timings shall be measured with respect to the appropriate threshold levels as defined in 4.3.2 to 4.3.6.

An electrical circuit is not active when the voltage with respect to contact GND remains between 0 V and 0,4 V for currents less than 1 mA flowing into the interface device.

4.3.2 VCC

This contact is used to provide the card with the power supply. In table 1, the current value is averaged over 1 ms. The maximum current is defined for the card. The interface device shall be able to deliver this current within the range specified for the voltage values and may deliver more.

Table 1 — Electrical characteristics of VCC under normal operating conditions

Symbol	Conditions	Minimum	Maximum	Unit
V_{CC}	Class A Class B	4,5 2,7	5,5 3,3	V
I_{CC}	Class A, at maximum allowed frequency Class B, at maximum allowed frequency When the clock is stopped (see 5.3.4)		60 50 0,5	mA

The power supply shall maintain the voltage value in the specified range despite transient power consumption as defined in table 2.

Table 2 — Spikes on I_{CC}

Class	Maximum charge [a]	Maximum duration	Maximum variation [b] of I_{cc}
A	20 nA.s	400 ns	100 mA
B	10 nA.s	400 ns	50 mA

[a] The maximum charge is half the product of the maximum duration and the maximum variation.
[b] The maximum variation is the difference in supply current with respect to the average value.

4.3.3 I/O

This contact is used as input (reception mode) or output (transmission mode). The information exchange through contact I/O uses the following two logic states as defined in ISO 1177:

— state Z if the card and the interface device are in reception mode or if this state is imposed by the transmitter;

— state A if this state is imposed by the transmitter.

When the two ends of the line are in reception mode, the line shall be at state Z (high state). When the two ends are in non-matched transmit mode, the logic state of the line may be indeterminate. During operation, the interface device and the card shall not both be in transmit mode.

The interface device shall be able to support the defined range of input currents when the input voltages are in the allowed range. The interface device shall present to the card an impedance such that it will not prevent the card from being able to keep the output voltages in the defined range.

Table 3 — Electrical characteristics of I/O under normal operating conditions

Symbol	Conditions	Minimum	Maximum	Unit
V_{IH}		0,70 x V_{CC}	V_{CC}	V
I_{IH}	V_{IH}	–300	+20	µA
V_{IL}		0	0,15 x V_{CC}	V
I_{IL}	V_{IL}	–1000	+20	µA
V_{OH}	External pull-up resistor: 20 kΩ to V_{CC}	0,70 x V_{CC}	V_{CC}	V
I_{OH}	V_{OH}		+20	µA
V_{OL}	I_{OL} = 1 mA [a]	0	0,15 x V_{CC}	V
t_R t_F	C_{IN} = 30 pF; C_{OUT} = 30 pF		1	µs

The voltage on I/O shall remain between – 0,3 V and V_{CC} + 0,3 V.

[a] Interface device implementations should not require the card to sink more than 500 µA.

4.3.4 CLK

This contact is used to provide the card with the clock signal. The actual value of the frequency of the clock signal is designated by *f*. See 5.2 and 6.5.2 for the ranges of values of *f*.

The duty cycle of the clock signal shall be between 40 % and 60 % of the period during stable operation. When switching the frequency from one value to another, care should be taken to ensure that no pulse is shorter than 40 % of the shortest period allowed by the card as defined in table 7. No information shall be exchanged when switching the frequency value. Two different times are recommended for switching the frequency value:

— immediately after the answer to reset, or

— immediately after a successful PPS exchange (see 7.4).

Table 4 — Electrical characteristics of CLK under normal operating conditions

Symbol	Conditions	Minimum	Maximum	Unit
V_{IH} I_{IH}	V_{IH}	0,70 x V_{CC} −20	V_{CC} +100	V µA
V_{IL} I_{IL}	V_{IL}	0 −100	0,5 +20	V µA
t_R t_F	C_{IN} = 30 pF		9 % of period	
The voltage on CLK shall remain between − 0,3 V and V_{CC} + 0,3 V.				

4.3.5 RST

This contact is used to provide the card with the reset signal according to either 5.3.2 (cold reset) or 5.3.3 (warm reset).

Table 5 — Electrical characteristics of RST under normal operating conditions

Symbol	Conditions	Minimum	Maximum	Unit
V_{IH} I_{IH}	V_{IH}	0,80 x V_{CC} −20	V_{CC} +150	V µA
V_{IL} I_{IL}	V_{IL}	0 −200	0,12 x V_{CC} +20	V µA
t_R t_F	C_{IN} = 30 pF		1	µs
The voltage on RST shall remain between − 0,3 V and V_{CC} + 0,3 V.				

4.3.6 VPP

Under class B operating conditions, this contact is reserved for future use.

Under class A operating conditions, this contact may be used to provide the card with the programming power required to write or to erase the internal non-volatile memory. Table 6 defines two activated states on contact VPP: pause state and programming state. The interface device shall maintain contact VPP at pause state unless the card requires the programming state.

Table 6 — Electrical characteristics of VPP under normal operating conditions

Symbol	Conditions	Minimum	Maximum	Unit
V_{PP} I_{PP}	Pause state	0,95 x V_{CC}	1,05 x V_{CC} 20	V mA
V_{PP} I_{PP}	Programming state	0,975 x P	1,025 x P I	V mA
t_R t_F		[a]	200	µs
The power shall not exceed 1,5 W when averaged over any period of 1 s. NOTES 1 When needed, the card provides the interface device with the values P and I (see 6.5.4). 2 VPP state control, as specified in clauses 8 and 9, is only relevant under class A operating conditions.				
[a] The rate of change of the voltage on VPP value shall not exceed 2 V.µs^{-1}.				

5 Card operating procedure

5.1 General overview

The electrical circuits shall not be activated until the contacts of the card are mechanically connected to the contacts of the interface device.

The interaction between the interface device and the card shall be conducted through the following consecutive operations specified in the subsequent subclauses.

— Activation of the electrical circuits by the interface device.

— Information exchange between the card and the interface device always initiated by the card answering to the cold reset.

— Deactivation of the electrical circuits by the interface device.

The sequence of deactivation of the electrical circuits should be concluded before the mechanical disconnection between the contacts of the card and the contacts of the interface device.

5.2 Activation

In order to initiate an interaction with a mechanically connected card, the interface device shall activate the electrical circuits in the following order shown on figure 2.

— RST shall be put to state L (see 4.3.5).

— VCC shall be powered according to the operating conditions selected by the interface device: class A or class B (see 4.3.2 and table 1).

— I/O in the interface device shall be put in reception mode (see 4.3.3).

— Under class A, VPP shall be put to pause state (see 4.3.6). Under class B, VPP is reserved for future use.

— CLK shall be provided with a clock signal (see 4.3.4). At least during the answer to reset, the frequency *f* of the clock signal shall lie in the range:

- 1 to 5 MHz under class A or
- 1 to 4 MHz under class B.

By the end of the sequence of activation of the electrical circuits (RST in state L, VCC powered, I/O in reception mode in the interface device, VPP at pause state when operating under class A, CLK provided with a suitable and stable clock signal), the card is ready for a cold reset according to the timing specified in 5.3.2 and figure 2.

5.3 Information exchange

5.3.1 General

If the card supports the class of operating conditions, then the card shall answer to any reset according to clause 6. After completion of any answer to reset, the interface device may initiate a warm reset of the card. The answer to a warm reset may differ from the answer to the previous, either cold or warm, reset. After completion of any answer to reset indicating the negotiable mode (see 6.6), the interface device may initiate a PPS exchange as specified in clause 7.

The operating procedure of commands depends on the transmission protocol. The half-duplex transmission of asynchronous characters with the interface device as the master is specified in clause 8. The half-duplex asynchronous transmission of blocks is specified in clause 9. When no transmission is expected from the card (e.g., after completion of a command and before initiating the next command), the interface device may even stop the clock signal if the card supports clock stop.

NOTE — ISO/IEC 7816-4 specifies interindustry commands for interchange. Other commands are specified either in existing standards or in additional standards to be defined.

5.3.2 Cold reset

According to figure 2, the clock signal is applied to CLK at time *Ta*. The card shall set the I/O line to state Z within 200 clock cycles of the clock signal (*ta*) being applied to CLK (time *ta* after *Ta*). The card is reset by maintaining RST at state L for at least 400 clock cycles (*tb*) after the clock signal is applied to CLK (time *tb* after *Ta*).

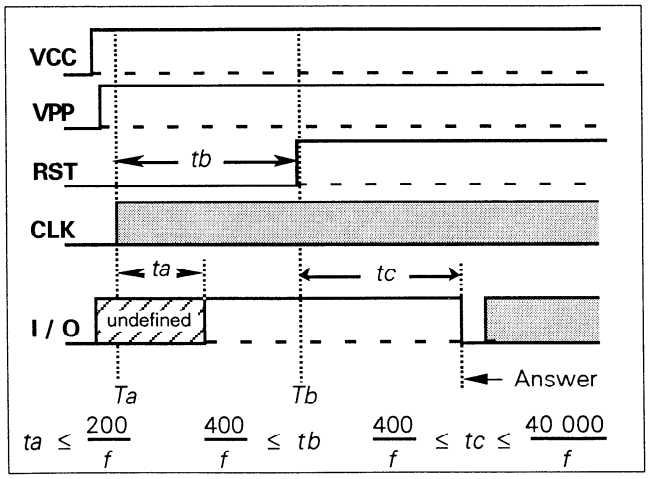

Figure 2 — Activation and cold reset

At time *Tb*, RST is put to state H. The answer on I/O shall begin between 400 and 40 000 clock cycles (*tc*) after the rising edge of the signal on RST (time *tc* after *Tb*).

If the answer does not begin within 40 000 clock cycles with RST at state H, the signal on RST shall be returned to state L and the electrical circuits shall be deactivated by the interface device according to 5.4.

NOTES

1 The internal state of the card is assumed not to be defined before a cold reset. Therefore the design of the card has to avoid improper operation.

2 The interface device may initiate a cold reset of the card at its discretion at any time.

5.3.3 Warm reset

According to figure 3, the interface device initiates a warm reset by putting RST to state L for at least 400 clock cycles (time *te*) while VCC and CLK remain stable.

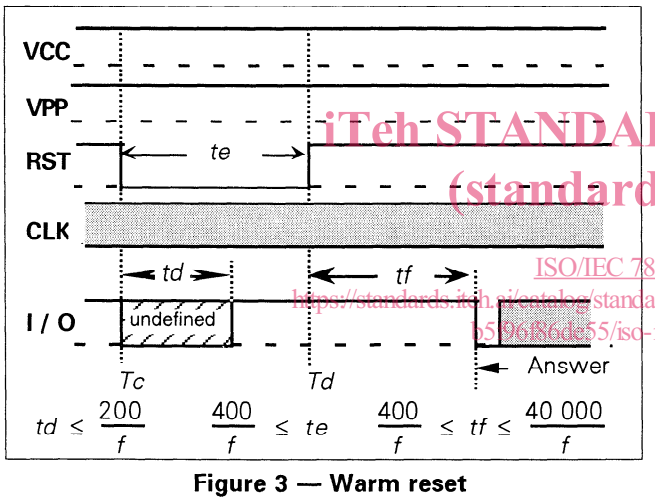

Figure 3 — Warm reset

At time *Td*, RST is put to state H. The answer on I/O shall begin between 400 and 40 000 clock cycles (*tf*) after the rising edge of the signal on RST (time *tf* after *Td*).

If the answer does not begin within 40 000 clock cycles with RST at state H, the signal on RST shall be returned to state L and the electrical circuits shall be deactivated by the interface device according to 5.4.

5.3.4 Clock stop

For cards supporting clock stop, when the interface device expects no transmission from the card and when I/O has remained at state Z for at least 1 860 clock cycles (time *tg*), then according to figure 4, the interface device may stop the clock on CLK (at time *Te*).

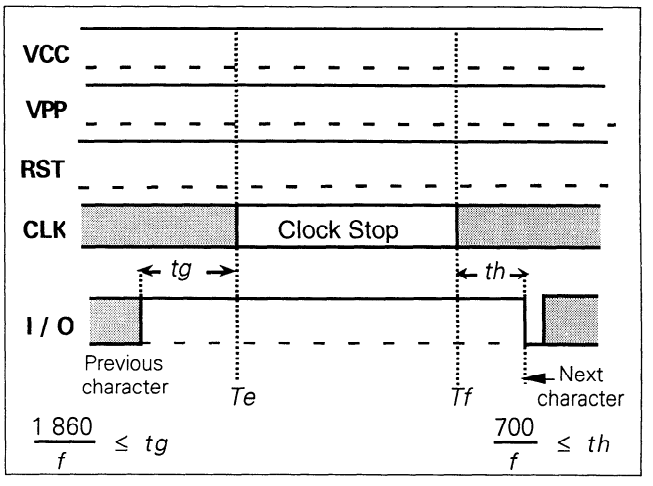

Figure 4 — Clock stop

When the clock is stopped (from time *Te* to time *Tf*), CLK shall be maintained either at state H or at state L; the state is indicated by parameter X as defined in 6.5.5.

At time *Tf*, the interface device restarts the clock and the information exchange on I/O may continue after at least 700 clock cycles (time *th* after *Tf*).

5.4 Deactivation

When information exchange is concluded or aborted (e.g., unresponsive card, detection of card removal), the interface device shall deactivate the electrical circuits in the following order shown on figure 5.

— RST shall be put to state L.

— CLK shall be put to state L (unless the clock is already stopped at state L).

— VPP shall be deactivated (if it has been activated).

— I/O shall be put to state A.

— VCC shall be deactivated.

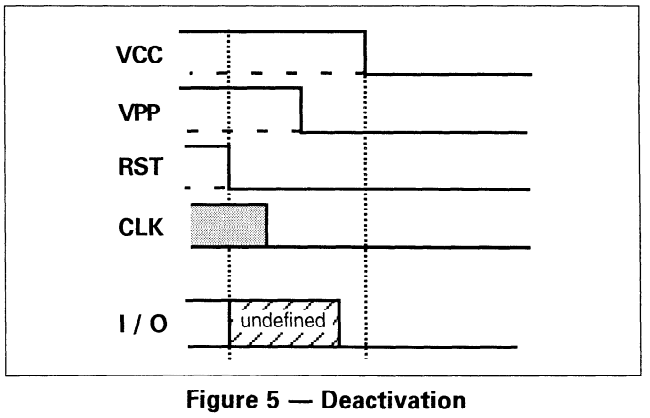

Figure 5 — Deactivation

6 Answer-to-Reset

6.1 General configuration

By definition, the Answer-to-Reset is the value of the sequence of bytes sent by the card to the interface device as the answer to a reset. On the I/O circuit, each byte is conveyed in an asynchronous character.

Each successful reset operation shall induce on I/O an initial character TS followed by at most 32 characters in the following order shown on figure 6.

T0 ..... Format character, mandatory

TA(i) TB(i) TC(i) TD(i) ..... Interface characters, optional

T1 T2 ...TK ..... Historical characters, optional

TCK ..... Check character, conditional

- The initial character sets up the convention to decode every subsequent character.
- The format character announces the first interface characters and all the historical characters.
- The presence of interface characters is indicated by a bit map technique initiated by the format character.
- The presence of historical characters is indicated by a number coded in the format character.
- The presence of the check character depends on the value(s) of parameter T in some interface bytes.

For notation simplicity, T0 TA(i) ... T1 ... TCK hereafter designate the bytes as well as the characters in which they are conveyed.

6.2 Parameter T

Parameter T refers to a transmission protocol and/or qualifies interface bytes. In every byte TD(i) (see 6.4.3.1), TA(2) (see 6.5.7) or PPS0 (see 7.3), the bits b4 to b1 code a value of parameter T.

— T=0 refers to the half-duplex transmission of asynchronous characters specified in clause 8.

— T=1 refers to the half-duplex asynchronous transmission of blocks specified in clause 9.

— T=2 and T=3 are reserved for future full-duplex operations.

— T=4 is reserved for an enhanced half-duplex transmission of asynchronous characters.

— T=5 to T=13 are reserved for future use.

— T=14 refers to transmission protocols not standardized by ISO/IEC JTC 1 SC 17.

— T=15 does not refer to a transmission protocol, but only qualifies global interface bytes (see 6.4.3.2).

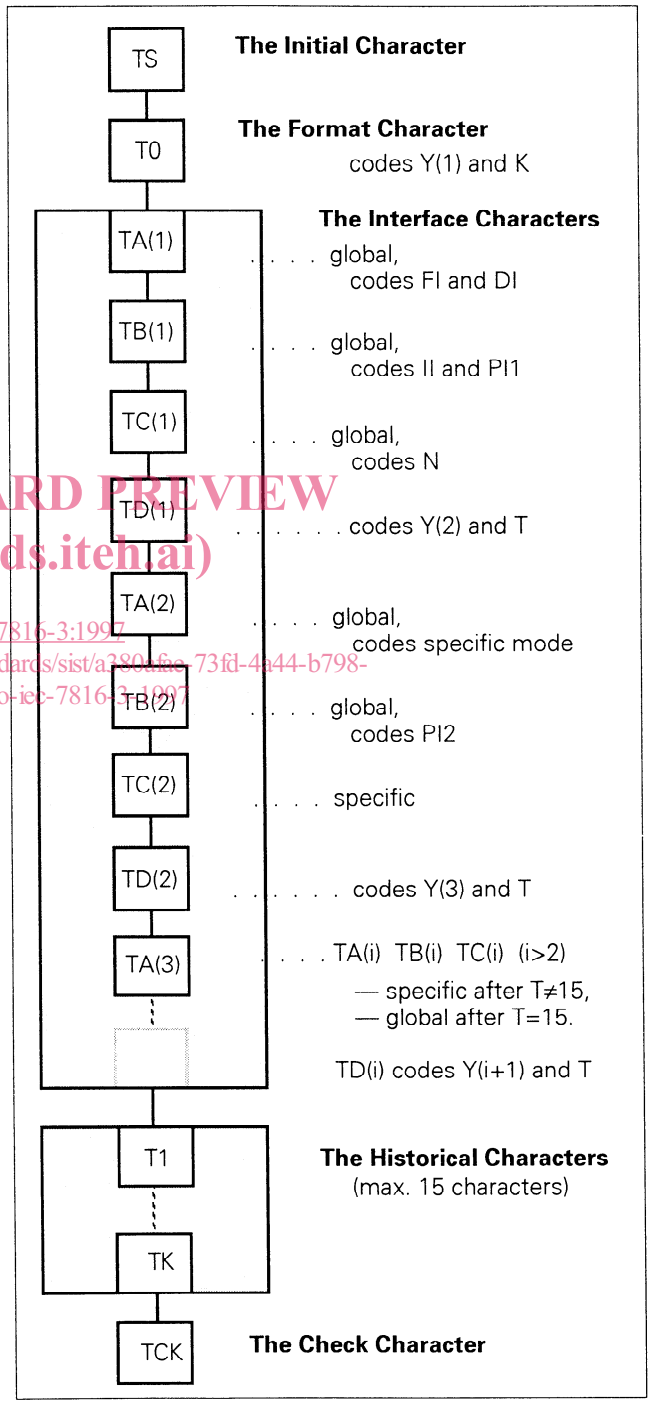

Figure 6 — Configuration of the Answer-to-Reset