EMV2000
Integrated Circuit Card Specification for Payment Systems

BOOK 1 – Amendment 1

Electromechanical Characteristics for Cards and Terminals operating at 5V, 3V and 1.8V

Draft Version 1.0
2001 – 11 – 30

The contents of this Amendment replace Section 1 of Book 1 of the *'EMV 2000 Integrated Circuit Card Specifications for Payment Systems'* dated December 2000

This section 1 shall be read in conjunction with the document '*Lower Voltage Card Migration – Proposed Mandatory Implementation Schedule'*, which defines when non-class A cards shall be issued and when non class A terminals may be implemented.

1. Electromechanical Interface

This section covers the electrical and mechanical characteristics of the ICC and the terminal. ICC and terminal specifications differ to allow a safety margin to prevent damage to the ICC.

The ICC characteristics defined herein are based on the ISO/IEC 7816 series of standards with some small variations.

1.1 Mechanical Characteristics of the ICC

This section describes the physical characteristics, contact assignment, and mechanical strength of the ICC.

1.1.1 Physical Characteristics

Except as otherwise specified herein, the ICC shall comply with the physical characteristics for ICCs as defined in ISO/IEC 7816-1. The ICC shall also comply with the additional characteristics defined in ISO/IEC 7816-1 as related to ultra-violet light, X-rays, surface profile of the contacts, mechanical strength, electromagnetic characteristics, and static electricity and shall continue to function correctly electrically under the conditions defined therein.

1.1.1.1 Module Height

The highest point on the IC module surface shall not be greater than 0.10mm above the plane of the card surface.

The lowest point on the IC module surface shall not be greater than 0.10mm below the plane of the card surface.

1.1.2 Dimensions and Location of Contacts

The dimensions and location of the contacts shall be as shown in Figure 1:

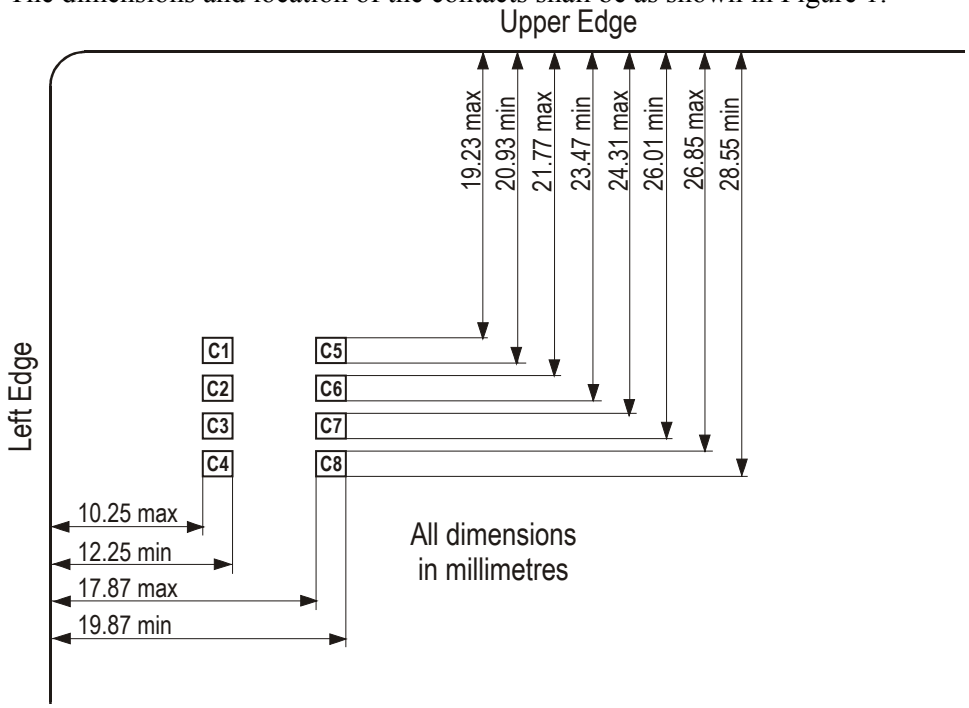
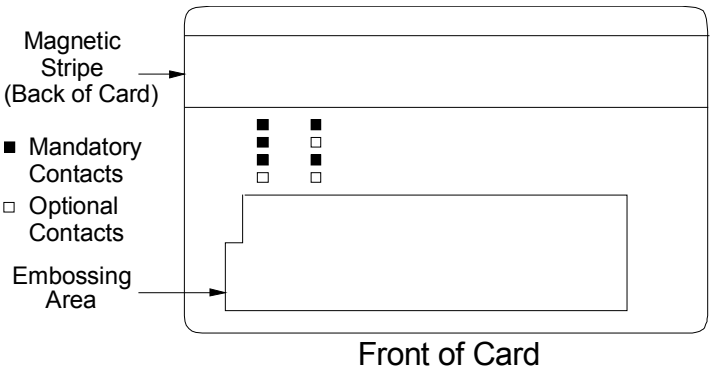


Figure 1 - ICC Contact Location and Dimensions

Areas C1, C2, C3, C5 and C7 shall be fully covered by conductive surfaces forming the minimum ICC contacts. Areas C4, C6, C8, and areas Z1 to Z8 as defined in ISO/IEC 7816-2 Annex B may optionally have conductive surfaces, but it is strongly recommended that no conductive surfaces exist in areas Z1 to Z8. If conductive surfaces exist in areas C6, and Z1 to Z8, they shall be electrically isolated[1] from the integrated circuit (IC), from one another, and from any other contact area. In addition, there shall be no connection between the conductive surface of any area and the conductive surface of any other area, other than via the IC. The minimum ICC contacts shall be connected to the IC contacts as shown in Table 1.

The layout of the contacts relative to embossing and/or magnetic stripe shall be as shown in Figure 2:



[1] Electrically isolated means that the resistance measured between the conductive surface and any other conductive surface shall be ≥10MΩ with an applied voltage of 5V DC.

Figure 2 - Layout of Contacts

Note: Care should be taken that card embossing does not damage the IC. Further, positioning of the signature panel behind the IC may lead to damage due to heavy pressure being applied during signature.

1.1.3 Contact Assignment

The assignment of the ICC contacts shall be as defined in ISO/IEC 7816-2 and is shown in Table 1:

C1	Supply voltage (VCC)	C5	Ground (GND)
C2	Reset (RST)	C6	RFU[2]
C3	Clock (CLK)	C7	Input/output (I/O)

Table 1 - ICC Contact Assignment

C4 and C8 are not used and need not be physically present.

1.2 Electrical Characteristics of the ICC

This section describes the electrical characteristics of the signals as measured at the ICC contacts.

1.2.1 Measurement Conventions

All measurements are made at the point of contact between the ICC and the interface device (IFD) contacts and are defined with respect to the GND contact over an ambient temperature range 0° C to 50° C. ICCs shall be capable of correct operation over an ambient temperature range of at minimum 0° C to 50° C.

All currents flowing into the ICC are considered positive.

Note: The temperature range limits are dictated primarily by the thermal characteristics of polyvinyl chloride (that is used for the majority of cards that are embossed) rather than by constraints imposed by the characteristics of the IC.

1.2.2 Input/Output (I/O)

This contact is used as an input (reception mode) to receive data from the terminal or as an output (transmission mode) to transmit data to the terminal. During operation, the ICC and the terminal shall not both be in transmit mode. In the event that this condition occurs, the state (voltage level) of the I/O contact is indeterminate and no damage shall occur to the ICC.

1.2.2.1 Reception Mode

When in reception mode, and with the supply voltage (VCC) for the applicable class in the range specified in section 1.2.6, the ICC shall correctly interpret signals from the terminal having the characteristics shown in Table 2:

[2] Defined in ISO/IEC 7816 as programming voltage (VPP) for class A.

Symbol	Conditions	Minimum	Maximum	Unit
V_{IH}		0.7 x V_{CC}	V_{CC}	V
V_{IL}	Class A Class B Class C	0 0 0	0.2 x V_{CC} 0.2 x V_{CC} 0.2 x V_{CC}	V
t_R and t_F		-	1.0	µs
The ICC shall not be damaged by signal perturbations on the I/O line in the range –0.3 V to V_{CC} + 0.3 V				

Table 2 - Electrical Characteristics of I/O for ICC Reception

1.2.2.2 Transmission Mode

When in transmission mode, the ICC shall send data to the terminal with the characteristics shown in Table 3:

Symbol	Conditions	Minimum	Maximum	Unit
V_{OH}	–20 µA < I_{OH} < 0	0.7 x V_{CC}	V_{CC}	V
V_{OL}	Class A, 0 < I_{OL} < 1 mA Class B, 0 < I_{OL} < 0.5 mA Class C, 0 < I_{OL} < 0.5 mA	0 0 0	0.08 x V_{CC} 0.08 x V_{CC} 0.08 x V_{CC}	V
t_R and t_F	C_{IN} (terminal) = 30 pF max.	-	1.0	µs

Table 3 - Electrical Characteristics of I/O for ICC Transmission

Unless transmitting, the ICC shall set its I/O line driver to reception mode. There is no requirement for the ICC to have any current source capability to I/O.

1.2.3 Programming Voltage (VPP)

The ICC shall not require VPP (see note in section 1.3.3).

1.2.4 Clock (CLK)

With VCC in the range specified for the applicable class in section 1.2.6, the ICC shall operate correctly with a CLK signal having the characteristics shown in Table 4:

Symbol	Conditions	Minimum	Maximum	Unit
V_{IH}		0.7 x V_{CC}	V_{CC}	V
V_{IL}	Class A Class B Class C	0 0 0	0.5 0.4 0.4	V
t_R and t_F		-	9% of clock period	
The ICC shall not be damaged by signal perturbations on the CLK line in the range –0.3 V to V_{CC} + 0.3 V.				

Table 4 - Electrical Characteristics of CLK to ICC

The ICC shall operate correctly with a CLK duty cycle of between 44% and 56% of the period during stable operation.

The ICC shall operate correctly with a CLK frequency in the range 1 MHz to 5 MHz.

Note: Frequency shall be maintained by the terminal to within ± 1% of that used during the answer to reset throughout the card session.

1.2.5 Reset (RST)

With VCC in the range specified for the applicable class in section 1.2.6, the ICC shall correctly interpret a RST signal having the characteristics shown in Table 5:

Symbol	Conditions	Minimum	Maximum	Unit
V_{IH}		0.8 x V_{CC}	V_{CC}	V
V_{IL}	Class A Class B Class C	0 0 0	0.2 x V_{CC} 0.2 x V_{CC} 0.2 x V_{CC}	V
t_R and t_F	V_{CC} = min. to max.	-	1.0	µs
The ICC shall not be damaged by signal perturbations on the RST line in the range -0.3 V to V_{CC} +0.3 V				

Table 5 - Electrical Characteristics of RST to ICC

The ICC shall answer to reset asynchronously using active low reset.

1.2.6 Supply Voltage (VCC)

Three classes of operation are defined based on the nominal supply voltage applied to the ICC. These are defined in Table XX below. The ICC shall support class A and may optionally support one or more additional consecutive classes. The ICC shall operate correctly on any supply voltage lying within the range(s) specified for the class(es) it supports.

Symbol	Conditions	Minimum	Maximum	Unit
V_{CC}	Class A Class B Class C	4.50 2.70 1.62	5.50 3.30 1.98	V
I_{CC}	Class A Class B Class C		50 50 30	mA
The maximum current consumptions shown apply when operating at any frequency within the range specified in section 1.2.4.				

Table XX – Classes of Operation

If the ICC supports more than one class, it may optionally operate correctly on any supply voltage lying between the ranges specified for the supported classes (see Table ZZ below).

Supported Classes	ICC Shall Operate	ICC May Operate	Unit
A and B	4.50 - 5.50 2.70 - 3.30	3.30 - 4.50	V
A, B and C	4.50 - 5.50 2.70 - 3.30 1.62 - 1.98	3.30 - 4.50 1.98 - 2.70	V

Table ZZ – Mandatory and Optional Operating Voltage Ranges

Note: It is strongly recommended that the current consumption of ICCs is maintained at as low a value as possible, since the maximum current consumption allowable for the ICC may be reduced in future versions of this specification. Issuers of ICCs bearing multisector applications should ensure that the IC used has a current requirement compatible with all terminals (from all sectors) in which the ICC might be used.

1.2.7 Contact Resistance

The contact resistance as measured across a pair of clean ICC and clean nominal IFD contacts shall be less than 500 mΩ throughout the design life of an ICC (see ISO/IEC 10373 for test method).

Note: A nominal IFD contact may be taken as a minimum of 1.25 μm of gold over 5.00 μm of nickel.

1.3 Mechanical Characteristics of the Terminal

This section describes the mechanical characteristics of the terminal interface device.

1.3.1 Interface Device

The IFD into which the ICC is inserted shall be capable of accepting ICCs having the following characteristics:

- Physical characteristics compliant with ISO/IEC DIS 7816-1

- Contacts on the front, in the position compliant with Figure 2 of ISO/IEC DIS 7816-2
- Embossing compliant with ISO/IEC 7811-1 and 3

The IFD contacts shall be located such that if an ICC having contacts with the dimensions and locations specified in Figure 3 is inserted into the IFD, correct connection of all contacts shall be made. The IFD should have no contacts present other than those needed to connect to ICC contacts C1 to C8.

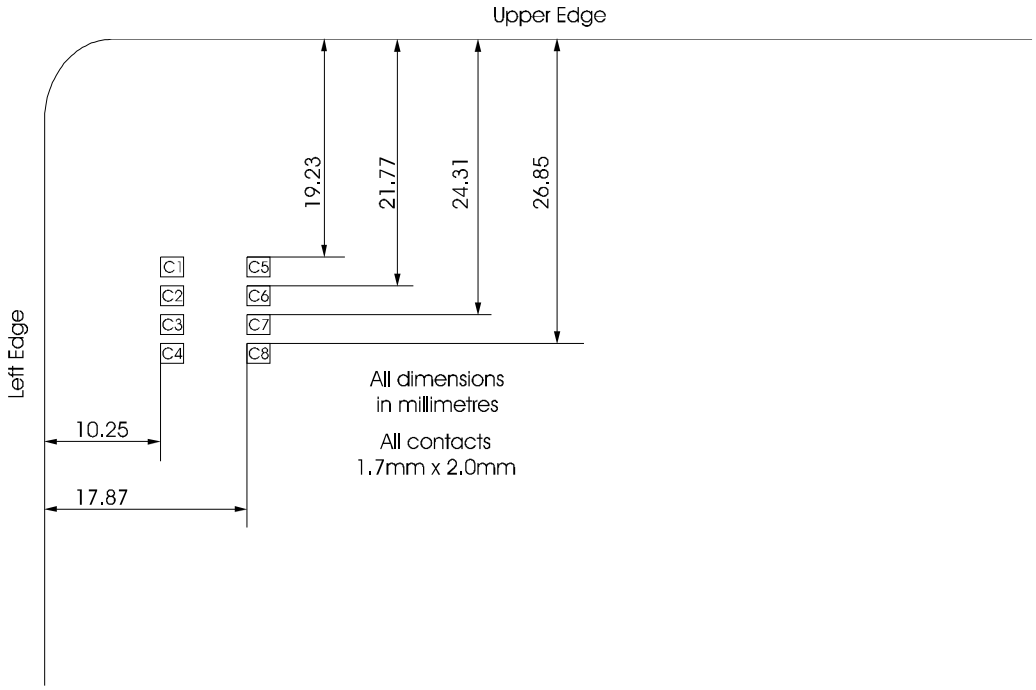


Figure 3 - Terminal Contact Location and Dimensions

Location guides and clamps (if used) should cause no damage to ICCs, particularly in the areas of the magnetic stripe, signature panel, embossing, and hologram.

Note: As a general principle, an ICC should be accessible to the cardholder at all times. Where the ICC is drawn into the IFD, a mechanism should exist to return the ICC to the cardholder in the event of a failure (for example, loss of power).

1.3.2 Contact Forces

The force exerted by any one IFD contact on the corresponding ICC contact shall be in the range 0.2 N to 0.6 N.

1.3.3 Contact Assignment

The assignment of the IFD contacts shall be as shown in Table 6:

C1	VCC	C5	GND
C2	RST	C6	Not used for class A, RFU for classes B & C[3]
C3	CLK	C7	I/O

Table 6 - IFD Contact Assignment

C4 and C8 are not used and need not be physically present.

1.4 Electrical Characteristics of the Terminal

This section describes the electrical characteristics of the signals as measured at the IFD contacts.

1.4.1 Measurement Conventions

All measurements are made at the point of contact between the ICC and the IFD contacts and are defined with respect to GND contact over an ambient temperature range 5° C to 40° C unless otherwise specified by the manufacturer. The internal temperature of the terminal should be limited to avoid damage to ICCs.

All currents flowing out of the terminal are considered positive.

1.4.2 Input/Output (I/O)

This contact is used as an output (transmission mode) to transmit data to the ICC or as an input (reception mode) to receive data from the ICC. During operation, the terminal and the ICC should not both be in transmit mode. In the event that this condition occurs, the state (voltage level) of the contact is indeterminate and no damage shall occur to the terminal.

When both the terminal and the ICC are in reception mode, the contact shall be in the high state. The terminal shall not pull I/O high unless VCC is powered and stable within the tolerances specified in section 1.4.6. See the contact activation sequence specified in section 2.1.2.

The terminal shall limit the current flowing into or out of the I/O contact to ±15 mA at all times.

1.4.2.1 Transmission Mode

When in transmission mode, the terminal shall send data to the ICC with the characteristics shown in Table 7:

[3] Defined in ISO/IEC 7816 as programming voltage (VPP) for class A.

Symbol	Conditions	Minimum	Maximum	Unit
V_{OH}	$0 < I_{OH} < 20\ \mu A$	$0.8 \times V_{CC}$	V_{CC}	V
V_{OL}	Class A, $-0.5\ mA < I_{OL} < 0$	0	$0.15 \times V_{CC}$	V
	Class B, $-0.5\ mA < I_{OL} < 0$	0	$0.15 \times V_{CC}$	
	Class C, $-0.5\ mA < I_{OL} < 0$	0	$0.15 \times V_{CC}$	
t_R and t_F	$C_{IN(ICC)} = 30$ pF max.	-	0.8	µs
Signal perturbations	Signal low	- 0.25	V_{OLmax}*	V
	Signal high	$0.8 \times V_{CC}$	$V_{CC} + 0.25$	V

* - for the applicable class

Table 7 - Electrical Characteristics of I/O for Terminal Transmission

Unless transmitting, the terminal shall set its I/O line driver to reception mode.

1.4.2.2 Reception Mode

When in reception mode, the terminal shall correctly interpret signals from the ICC having the characteristics shown in Table 8:

Symbol	Conditions	Minimum	Maximum	Unit
V_{IH}		$0.6 \times V_{CC}$	V_{CC}	V
V_{IL}	Class A	0	$0.12 \times V_{CC}$	V
	Class B	0	$0.12 \times V_{CC}$	
	Class C	0	$0.12 \times V_{CC}$	
t_R and t_F		-	1.2	µs

Table 8 - Electrical Characteristics of I/O for Terminal Reception

1.4.3 Programming Voltage (VPP)

C6 shall be electrically isolated. Electrically isolated means that the resistance measured between C6 and any other contact shall be ≥10MΩ with an applied voltage of 5V DC. If connected in existing class A terminals, C6 shall be maintained at a potential between GND and $1.05 \times V_{CC}$ throughout the card session.

Note: Keeping C6 isolated in new class A terminals facilitates its use for other purposes if so defined in future versions of this specification.

1.4.4 Clock (CLK)

The terminal shall generate a CLK signal having the characteristics shown in Table 9:

Symbol	Conditions	Minimum	Maximum	Unit
V_{OH}	$0 < I_{OH} < 50$ µA	0.8 x V_{CC}	V_{CC}	V
V_{OL}	Class A - 50 µA < I_{OL} < 0	0	0.4	V
	Class B - 50 µA < I_{OL} < 0	0	0.3	
	Class C - 50 µA < I_{OL} < 0	0	0.3	
t_R and t_F	$C_{IN(ICC)}$ = 30 pF max.	-	8% of clock period	
Signal perturbations	Signal low	- 0.25	V_{OLmax}*	V
	Signal high	0.8 x V_{CC}	V_{CC} + 0.25	V

* - for the applicable class

Table 9 - Electrical Characteristics of CLK from Terminal

Duty cycle shall be between 45% and 55% of the period during stable operation.

Frequency shall be in the range 1 MHz to 5 MHz and shall not change by more than ± 1% throughout answer to reset and the following stages of a card session (see section 2) unless changed following the answer to reset by means of a proprietary negotiation technique.

1.4.5 Reset (RST)

The terminal shall generate a RST signal having the characteristics shown in Table 10:

Symbol	Conditions	Minimum	Maximum	Unit
V_{OH}	$0 < I_{OH} < 50$ µA	0.9 x V_{CC}	V_{CC}	V
V_{OL}	Class A, - 50 µA < I_{OL} < 0	0	0.12 x V_{CC}	V
	Class B, - 50 µA < I_{OL} < 0	0	0.12 x V_{CC}	
	Class C, - 50 µA < I_{OL} < 0	0	0.12 x V_{CC}	
t_R and t_F	$C_{IN(ICC)}$ = 30 pF max.	-	0.8	µs
Signal perturbations	Signal low	- 0.25	V_{OLmax}*	V
	Signal high	0.9 x V_{CC}	V_{CC} + 0.25	V

* - for the applicable class

Table 10 - Electrical Characteristics of RST from Terminal

1.4.6 Supply Voltage (VCC)

The terminal shall generate a V_{CC} within one of the range(s) specified in Table YY below for the class(es) supported, and shall be capable of delivering the corresponding steady state output current whilst maintaining V_{CC} within that range. If the terminal supports more than one class, it shall always generate a V_{CC} from the class containing the highest voltage range available. For proprietary reasons terminals may support the capability to negotiate with the ICC the voltage class to be used, but this is outside the scope of EMV, and is not supported by ICCs conforming to this specification. Attempting class negotiation with such an ICC

may result in the ICC being rejected. The supply shall be protected from transients and surges caused by internal operation of the terminal and from external interference introduced via power leads, communications links, etc. V_{CC} shall never be less than -0.25V with respect to ground.

Symbol	Conditions	Minimum	Maximum	Unit
V_{CC}	Class A Class B Class C	4.60 2.76 1.66	5.40 3.24 1.94	V
I_{CC}	Class A Class B Class C	55 55 35		mA

Table YY – Terminal Supply Voltage and Current

During normal operation of an ICC, current pulses cause voltage transients on VCC as measured at the ICC contacts. The power supply shall be able to counteract transients in the current consumption of the ICC having characteristics within the maximum charge envelope applicable to the class of operation as shown in Figure 4, ensuring that VCC remains within the range specified.

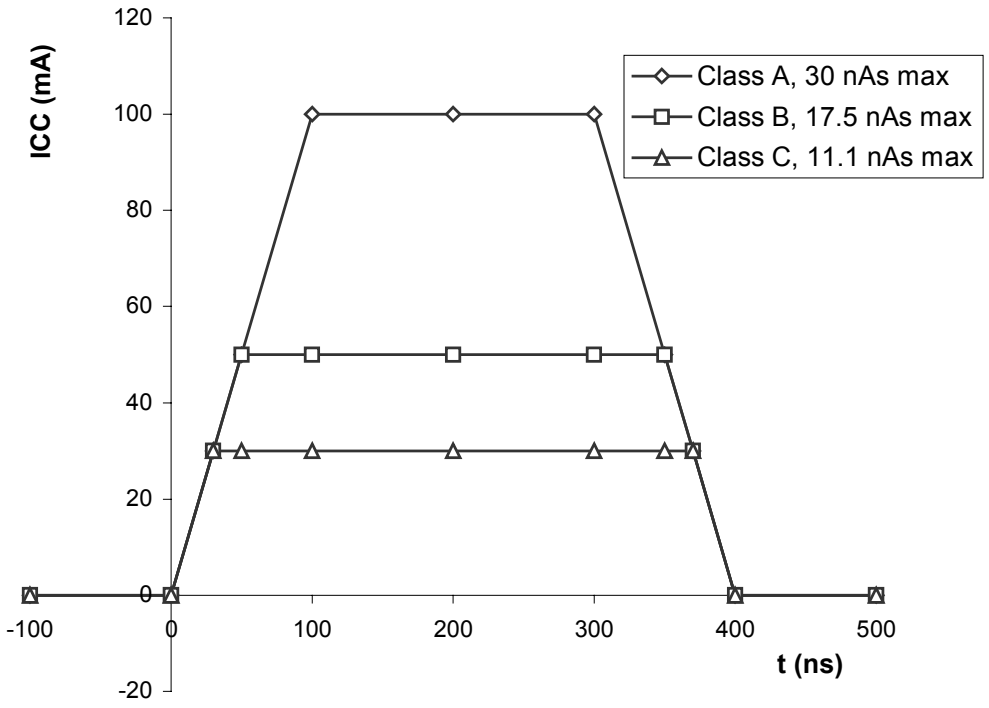


Figure 4 - Maximum Current Pulse Envelopes

Note: Terminals may be designed to be capable of delivering more than required current, but it is recommended that terminals limit the steady state current that can be delivered to a maximum of 200 mA.

1.4.7 Contact Resistance

The contact resistance as measured across a pair of clean IFD and clean nominal ICC contacts shall be less than 500 mΩ throughout the design life of a terminal (see ISO/IEC DIS 7816-1 for test method).

Note: A nominal ICC contact may be taken as 1.25 μm of gold over 5.00 μm of nickel.

1.4.8 Short Circuit Resilience

The terminal shall not be damaged in the event of fault conditions such as a short circuit between any combinations of contacts. The terminal shall be capable of sustaining a short circuit of any duration between any or all contacts without suffering damage or malfunction, for example, if a metal plate is inserted.

1.4.9 Powering and Depowering of Terminal with ICC in Place

If the terminal is powered on or off with an ICC in place, all signal voltages shall remain within the limits specified in section 1.4, and contact activation and deactivation sequences and timings, as described in sections 2.1.2 and 2.1.5 respectively, shall be respected.