Advanced Card Systems Ltd.
Card & Reader Technologies

ACR38 CCID Smart Card Reader

Reference Manual

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1.0. Introduction

The ACS Smart Card Reader/Writer ACR38 CCID acts as an interface for the communication between a computer (for example, a PC) and a smart card. Different types of smart cards have different commands and different communication protocols and this prevents in most cases the direct communication between a smart card and a computer. The ACR38 CCID establishes a uniform interface from the computer to the smart card for a wide variety of cards. By taking care of the card specific particulars, it releases the computer software programmer of getting involved with the technical details of the smart card operation, which are in many cases not relevant for the implementation of a smart card system.

The ACR38 CCID Smart Card Reader/Writer is connected to the computer through USB interface and uses CCID interface to communicate with the USB port. CCID is the Device Class Specification for USB chip/Smart Card Interface Devices, and defines the communication protocol and commands for the USB chip-card interface devices.

NOTE - Although the ACR38 CCID is a true *card reader/writer* as it can read and write smart cards, the terms *card reader* or *reader* will be used indifferently to refer to the ACR38 CCID, for the sake of readability and because these designations are commonly in use for this kind of devices.

2.0. Features

- Conforms to: EN 60950/IEC 60950, ISO-7816, PC/SC, CCID, CE, FCC, Microsoft WHQL, EMV 2000 Level 1, FIPS 201
- Supports ISO-7816 Class A, B and C (5V, 3V, 1.8V) cards
- Read and write support to all microprocessor cards with T=0 or T=1 protocols
- Supports memory-based smart cards, including I2C bus protocol cards (from 1k bits up to 1024k bits) and Secure memory cards (Atmel AT88SC153 and AT88SC1608) and Memory Card with Security Logic (AT88SC101/102/1003)
- Supports SLE 4404/06/18/28/32/36/42, SLE 5518/28/32/36/42, SLE6636 memory cards
- Support PPS (Protocol and Parameters Selection) with 1,953 – 344,086 bps in reading and writing smart cards
- USB full speed interface to PC
- Short Circuit Protection
- RoHS Compliant

3.0. Supported Card Types

3.1. Microcontroller-based Smart Cards (Asynchronous Interface)

The ACR38 CCID supports Microcontroller-based smart cards with T=0 or T=1 protocol. ACR38 CCID performs the Protocol and Parameters Selection (PPS) procedure as specified *in ISO7816-3: 1997*. You can refer to the document entitled **ACR38 CCID Smart Card Reader Application Note: Memory Card Access** for the card commands for the most common memory cards in the market.

3.2. Memory-based Smart Cards (Synchronous Interface)

The ACR38 CCID works with several memory-based smart cards such as:

- Cards following the I2Cbus protocol (free memory cards) with maximum 128 bytes page with capability, including:

  Atmel: AT24C01/02/04/08/16/32/64/128/256/512/1024

  SGS-Thomson: ST14C02C, ST14C04C

  Gemplus: GFM1K, GFM2K, GFM4K, GFM8K

- Cards with secure memory IC with password and authentication, including:

  Atmel: AT88SC153 and AT88SC1608

- Cards with intelligent 1k bytes EEPROM with write-protect function, including:

  Infineon: SLE4418, SLE4428, SLE5518 and SLE5528

- Cards with intelligent 256 bytes EEPROM with write-protect function, including:

  Infineon: SLE4432, SLE4442, SLE5532 and SLE5542

- Cards with '104' type EEPROM non-reloadable token counter cards, including:

  Infineon: SLE4406, SLE4436, SLE5536 and SLE6636

- Cards with Intelligent 416-Bit EEPROM with internal PIN check, including:

  Infineon: SLE4404

- Cards with Security Logic with Application Zone(s), including:

  Atmel: AT88SC101, AT88SC102 and AT88SC1003

4.0. Smart Card Interface

The interface between the ACR38 CCID and the inserted smart card follows the specifications of *ISO7816-3* with certain restrictions or enhancements to increase the practical functionality of the ACR38 CCID.

4.1. Smart Card Power Supply VCC (C1)

The current consumption of the inserted card must not be higher than 50 **mA**.

4.2. Programming Voltage VPP (C6)

According to ISO 7816-3, the smart card contact C6 (VPP) supplies the programming voltage to the smart card. Since all common smart cards in the market are EEPROM based and do not require the provision of an external programming voltage, the contact C6 (VPP) has been implemented as a normal control signal in the ACR38 CCID. The electrical specifications of this contact are identical to those of the signal RST (at contact C2).

4.3. Card Type Selection

The controlling PC has to always select the card type through the proper command sent to the ACR38 CCID prior to activating the inserted card. This includes both the memory cards and MCU-based cards.

For MCU-based cards the reader allows to select the preferred protocol, T=0 or T=1. However, this selection is only accepted and carried out by the reader through the PPS when the card inserted in the reader supports both protocol types. Whenever an MCU-based card supports only one protocol type, T=0 or T=1, the reader automatically uses that protocol type, regardless of the protocol type selected by the application.

4.4. Interface for Microcontroller-based Cards

For microcontroller-based smart cards only the contacts C1 (VCC), C2 (RST), C3 (CLK), C5 (GND) and C7 (I/O) are used. A frequency of 4 MHz is applied to the CLK signal (C3).

4.5. Card Tearing Protection

The ACR38 CCID provides a mechanism to protect the inserted card when it is suddenly withdrawn while it is powered up. The power supply to the card and the signal lines between the ACR38 CCID and the card are immediately deactivated when the card is being removed. As a general rule, however, to avoid any electrical damage, **a card should only be removed from the reader while it is powered down.**

> **NOTE** - The ACR38 CCID does never by itself switch on the power supply to the inserted card. This must explicitly be done by the controlling computer through the proper command sent to the reader.

5.0. Power Supply

The ACR38 CCID requires a voltage of 5V DC, 100mA, regulated, power supply. The ACR38 CCID gets the power supply from PC (through the cable supplied along with each type of reader).

5.1. Status LED

Green LED on the front of the reader indicate the activation status of the smart card interface:

- **Flashing slowly (turns on 200ms for every 2 seconds)**

  Indicates ACR38 CCID is powered up and in the standby state. Either the smart card has not been inserted or the smart card has not been powered up (if it is inserted).

- **Lighting up**

  Indicates power supply to the smart card is switched on, i.e., the smart card is activated.

- **Flashing quickly**

  Indicates there are communications between ACR38 CCID and smart card.

6.0. USB Interface

The ACR38 CCID is connected to a computer through a USB following the USB standard.

6.1. Communication Parameters

The ACR38 CCID is connected to a computer through USB as specified in the USB Specification 1.1. The ACR38 CCID is working in full speed mode, i.e. 12 Mbps.

Pin	Signal	Function
1	**V_{BUS}**	+5V power supply for the reader
2	**D-**	Differential signal transmits data between ACR30 and PC.
3	**D+**	Differential signal transmits data between ACR30 and PC.
4	**GND**	Reference voltage level for power supply

Table 1. USB Interface Wiring

NOTE - In order for the ACR38 CCID to function properly through USB interface, either **ACS proprietary device driver** or **ACS PC/SC device driver** has to be installed. Please refer to the *Device Driver Installation Guide* for more detail.

6.2. Endpoints

The ACR38 CCID uses the following endpoints to communicate with the host computer:

Control Endpoint	For setup and control purpose
Bulk OUT	For command to sent from host to ACR38 CCID (data packet size is 64 bytes)
Bulk IN	For response to sent from ACR38 CCID to host (data packet size is 64 bytes)
Interrupt IN	For card status message to sent from ACR38 CCID to host (data packet size is 8 bytes)

7.0. Communication Protocol

ACR38 CCID shall interface with the host with USB connection. A specification, namely CCID, has been released within the industry defining such a protocol for the USB chip-card interface devices. CCID covers all the protocols required for operating smart cards and PIN.

The configurations and usage of USB endpoints on ACR38 CCID shall follow CCID section 3. An overview is summarized below:

1. *Control Commands* are sent on control pipe (default pipe). These include class-specific requests and USB standard requests. Commands that are sent on the default pipe report information back to the host on the default pipe.
2. *CCID Events* are sent on the interrupt pipe.
3. *CCID Commands* are sent on BULK-OUT endpoint. Each command sent to ACR38 CCID has an associated ending response. Some commands can also have intermediate responses.
4. *CCID Responses* are sent on BULK-IN endpoint. All commands sent to ACR38 CCID have to be sent synchronously. (i.e. bMaxCCIDBusySlots is equal to 1 for ACR38 CCID)

The supported CCID features by ACR38 CCID are indicated in its Class Descriptor:

Offset	Field	Size	Value	Description
0	bLength	1	36h	Size of this descriptor, in bytes.
1	bDescriptorType	1	21h	CCID Functional Descriptor type.
2	bcdCCID	2	0100h	CCID Specification Release Number in Binary-Coded decimal.
4	bMaxSlotIndex	1	00h	One slot is available on ACR38 CCID.
5	bVoltageSupport	1	07h	ACR38 CCID can supply 1.8V, 3.0V and 5.0V to its slot.
6	dwProtocols	4	00000003h	ACR38 CCID supports T=0 and T=1 Protocol
10	dwDefaultClock	4	00000FA0h	Default ICC clock frequency is 4MHz
14	dwMaximumClock	4	00000FA0h	Maximum supported ICC clock frequency is 4MHz
18	bNumClockSupported	1	00h	Does not support manual setting of clock frequency
19	dwDataRate	4	00002A00h	Default ICC I/O data rate is 10752 bps
23	dwMaxDataRate	4	0001F808h	Maximum supported ICC I/O data rate is 250000 bps
27	bNumDataRatesSupported	1	00h	Does not support manual setting of data rates
28	dwMaxIFSD	4	00000Feh	Maximum IFSD supported by ACR38 CCID for protocol T=1 is 254
32	dwSynchProtocols	4	00000000h	ACR38 CCID does not support synchronous card
36	dwMechanical	4	00000000h	ACR38 CCID does not support special mechanical characteristics
40	dwFeatures	4	00010030h	ACR38 CCID supports the following features: • Automatic ICC clock frequency change according to parameters • Automatic baud rate change according to frequency and FI,DI parameters • TPDU level exchange with ACR38 CCID
44	dwMaxCCIDMessageLength	4	0000010Fh	Maximum message length accepted by ACR38 CCID is 271 bytes

48	bClassGetResponse	1	00h	Insignificant for TPDU level exchanges
49	bClassEnvelope	1	00h	Insignificant for TPDU level exchanges
50	wLCDLayout	2	0000h	No LCD
52	bPINSupport	1	00h	No PIN Verification
53	bMaxCCIDBusySlots	1	01h	Only 1 slot can be simultaneously busy

8.0. Commands

8.1. CCID Command Pipe Bulk-OUT Messages

ACR38 CCID shall follow the CCID Bulk-OUT Messages as specified in CCID section 4. In addition, this specification defines some extended commands for operating additional features. This section lists the CCID Bulk-OUT Messages to be supported by ACR38 CCID.

8.1.1. PC_to_RDR_IccPowerOn

Activate the card slot and return ATR from the card.

Offset	Field	Size	Value	Description
0	bMessageType	1	62h	
1	dwLength	4	00000000h	Size of extra bytes of this message
2	bSlot	1		Identifies the slot number for this command
5	bSeq	1		Sequence number for command
6	bPowerSelect	1		Voltage that is applied to the ICC 00h – Automatic Voltage Selection 01h – 5 volts 02h – 3 volts
7	abRFU	2		Reserved for future use

The response to this message is the RDR_to_PC_DataBlock message and the data returned is the Answer To Reset (ATR) data.

8.1.2. PC_to_RDR_IccPowerOff

Deactivate the card slot.

Offset	Field	Size	Value	Description
0	bMessageType	1	63h	
1	dwLength	4	00000000h	Size of extra bytes of this message
5	bSlot	1		Identifies the slot number for this command
6	bSeq	1		Sequence number for command
7	abRFU	3		Reserved for future use

The response to this message is the RDR_to_PC_SlotStatus message.

8.1.3. PC_to_RDR_GetSlotStatus

Get current status of the slot.

Offset	Field	Size	Value	Description
0	bMessageType	1	65h	
1	dwLength	4	00000000h	Size of extra bytes of this message
5	bSlot	1		Identifies the slot number for this command
6	bSeq	1		Sequence number for command
7	abRFU	3		Reserved for future use

The response to this message is the RDR_to_PC_SlotStatus message.

8.1.4. PC_to_RDR_XfrBlock

Transfer data block to the ICC.

Offset	Field	Size	Value	Description
0	bMessageType	1	6Fh	
1	dwLength	4		Size of abData field of this message
5	bSlot	1		Identifies the slot number for this command
6	bSeq	1		Sequence number for command
7	bBWI	1		Used to extend the CCIDs Block Waiting Timeout for this current transfer. The CCID will timeout the block after “this number multiplied by the Block Waiting Time” has expired.
8	wLevelParameter	2	0000h	RFU (TPDU exchange level)
10	abData	Byte array		Data block sent to the CCID. Data is sent “as is” to the ICC (TPDU exchange level)

The response to this message is the RDR_to_PC_DataBlock message.

8.1.5. PC_to_RDR_GetParameters

Get slot parameters.

Offset	Field	Size	Value	Description
0	bMessageType	1	6Ch	
1	DwLength	4	00000000h	Size of extra bytes of this message
5	BSlot	1		Identifies the slot number for this command
6	BSeq	1		Sequence number for command
7	AbRFU	3		Reserved for future use

The response to this message is the RDR_to_PC_Parameters message.

8.1.6. PC_to_RDR_ResetParameters

Reset slot parameters to default value.

Offset	Field	Size	Value	Description
0	bMessageType	1	6Dh	
1	DwLength	4	00000000h	Size of extra bytes of this message
5	BSlot	1		Identifies the slot number for this command
6	BSeq	1		Sequence number for command
7	AbRFU	3		Reserved for future use

The response to this message is the RDR_to_PC_Parameters message.

8.1.7. PC_to_RDR_SetParameters

Set slot parameters.

Offset	Field	Size	Value	Description
0	bMessageType	1	61h	
1	dwLength	4		Size of extra bytes of this message
5	bSlot	1		Identifies the slot number for this command
6	bSeq	1		Sequence number for command
7	bProtocolNum	1		Specifies what protocol data structure follows. 00h = Structure for protocol T=0 01h = Structure for protocol T=1 The following values are reserved for future use. 80h = Structure for 2-wire protocol 81h = Structure for 3-wire protocol 82h = Structure for I2C protocol
8	abRFU	2		Reserved for future use
10	abProtocolDataStructure	Byte array		Protocol Data Structure

Protocol Data Structure for Protocol T=0 (dwLength=00000005h)

Offset	Field	Size	Value	Description
10	bmFindexDindex	1		B7-4 – FI – Index into the table 7 in ISO/IEC 7816-3:1997 selecting a clock rate conversion factor B3-0 – DI - Index into the table 8 in ISO/IEC 7816-3:1997 selecting a baud rate conversion factor
11	bmTCCKST0	1		B0 – 0b, B7-2 – 000000b B1 – Convention used (b1=0 for direct, b1=1 for inverse) Note: The CCID ignores this bit.
12	bGuardTimeT0	1		Extra Guardtime between two characters. Add 0 to 254 etu to the normal guardtime of 12etu. FFh is the same as 00h.
13	bWaitingIntegerT0	1		WI for T=0 used to define WWT
14	bClockStop	1		ICC Clock Stop Support 00h = Stopping the Clock is not allowed 01h = Stop with Clock signal Low 02h = Stop with Clock signal High 03h = Stop with Clock either High or Low

Protocol Data Structure for Protocol T=1 (dwLength=00000007h)

Offset	Field	Size	Value	Description
10	bmFindexDindex	1		B7-4 – FI – Index into the table 7 in ISO/IEC 7816-3:1997 selecting a clock rate conversion factor B3-0 – DI - Index into the table 8 in ISO/IEC 7816-3:1997 selecting a baud rate conversion factor
11	BmTCCKST1	1		B7-2 – 000100b B0 – Checksum type (b0=0 for LRC, b0=1 for CRC B1 – Convention used (b1=0 for direct, b1=1 for inverse) Note: The CCID ignores this bit.
12	BGuardTimeT1	1		Extra Guardtime (0 to 254 etu between two characters). If value is FFh, then guardtime is reduced by 1 etu.
13	BwaitingIntegerT1	1		B7-4 = BWI values 0-9 valid B3-0 = CWI values 0-Fh valid
14	bClockStop	1		ICC Clock Stop Support 00h = Stopping the Clock is not allowed 01h = Stop with Clock signal Low 02h = Stop with Clock signal High 03h = Stop with Clock either High or Low
15	bIFSC	1		Size of negotiated IFSC
16	bNadValue	1	00h	Only support NAD = 00h

The response to this message is the RDR_to_PC_Parameters message.

8.2. CCID Bulk-IN Messages

The Bulk-IN messages are used in response to the Bulk-OUT messages. ACR38 CCID shall follow the CCID Bulk-IN Messages as specified in CCID section 4. This section lists the CCID Bulk-IN Messages to be supported by ACR38 CCID.

8.2.1. RDR_to_PC_DataBlock

This message is sent by ACR38 CCID in response to PC_to_RDR_IccPowerOn, PC_to_RDR_XfrBlock and PC_to_RDR_Secure messages.

Offset	Field	Size	Value	Description
0	bMessageType	1	80h	Indicates that a data block is being sent from the CCID
1	dwLength	4		Size of extra bytes of this message
5	bSlot	1		Same value as in Bulk-OUT message
6	bSeq	1		Same value as in Bulk-OUT message
7	bStatus	1		Slot status register as defined in CCID section 4.2.1
8	bError	1		Slot error register as defined in CCID section 4.2.1 and this specification section 5.2.8
9	bChainParameter	1	00h	RFU (TPDU exchange level)
10	abData	Byte array		This field contains the data returned by the CCID

8.2.2. RDR_to_PC_SlotStatus

This message is sent by ACR38 CCID in response to PC_to_RDR_IccPowerOff, PC_to_RDR_GetSlotStatus, PC_to_RDR_Abort messages and Class specific ABORT request.

Offset	Field	Size	Value	Description
0	bMessageType	1	81h	
1	dwLength	4	00000000h	Size of extra bytes of this message
5	bSlot	1		Same value as in Bulk-OUT message
6	bSeq	1		Same value as in Bulk-OUT message
7	bStatus	1		Slot status register as defined in CCID section 4.2.1
8	bError	1		Slot error register as defined in CCID section 4.2.1 and this specification section 5.2.8
9	bClockStatus	1		value = 00h Clock running 01h Clock stopped in state L 02h Clock stopped in state H 03h Clock stopped in an unknown state All other values are RFU.

8.2.3. RDR_to_PC_Parameters

This message is sent by ACR38 CCID in response to PC_to_RDR_GetParameters, PC_to_RDR_ResetParameters and PC_to_RDR_SetParameters messages.

Offset	Field	Size	Value	Description
0	bMessageType	1	82h	
1	dwLength	4		Size of extra bytes of this message
5	bSlot	1		Same value as in Bulk-OUT message
6	bSeq	1		Same value as in Bulk-OUT message
7	bStatus	1		Slot status register as defined in CCID section 4.2.1
8	bError	1		Slot error register as defined in CCID section 4.2.1 and this specification section 5.2.8
9	bProtocolNum	1		Specifies what protocol data structure follows. 00h = Structure for protocol T=0 01h = Structure for protocol T=1 The following values are reserved for future use. 80h = Structure for 2-wire protocol 81h = Structure for 3-wire protocol 82h = Structure for I2C protocol
10	abProtocolDataStructure	Byte array		Protocol Data Structure as summarized in section 5.2.3.

8.3. Other Commands Access via *PC_to_RDR_XfrBlock*

8.3.1. GET_READER_INFORMATION

This command returns relevant information about the particular ACR38 model and the current operating status, such as, the firmware revision number, the maximum data length of a command and response, the supported card types, and whether a card is inserted and powered up.

Note: This command can only be used after the logical smart card reader communication has been established using the SCardConnect( ) API. For details of ScardConnect( ) API, please refer to PC/SC specification.

Pseudo-APDU				
CLA	INS	P1	P2	Lc
FF $_H$	09 $_H$	00 $_H$	00 $_H$	10 $_H$

Table 2. Command format (abData field in the PC_to_RDR_XfrBlock)

FIRMWARE										MAX_C	MAX_R	C_TYPE		C_SEL	C_STAT

Table 3. Response data format (abData field in the RDR_to_PC_DataBlock)

FIRMWARE 10 bytes data for firmware version

MAX_C The maximum number of command data bytes.

MAX_R The maximum number of data bytes that can be requested to be transmitted in a response.

C_TYPE The card types supported by the ACR38. This data field is a bitmap with each bit representing a particular card type. A bit set to '1' means the corresponding card type is supported by the reader and can be selected with the *SELECT_CARD_TYPE* command. The bit assignment is as follows:

Byte	1								2							
card type	F	E	D	C	B	A	9	8	7	6	5	4	3	2	1	0

See Appendix A for the correspondence between these bits and the respective card types.

C_SEL The currently selected card type. A value of 00_H means that no card type has been selected.

C_STAT Indicates whether a card is physically inserted in the reader and whether the card is powered up:

00_H: no card inserted

01_H: card inserted, not powered up

03_H: card powered up

Appendix A. Supported Card Types

The following table summarizes the card type returned by GET_READER_INFORMATION correspond with the respective card type.

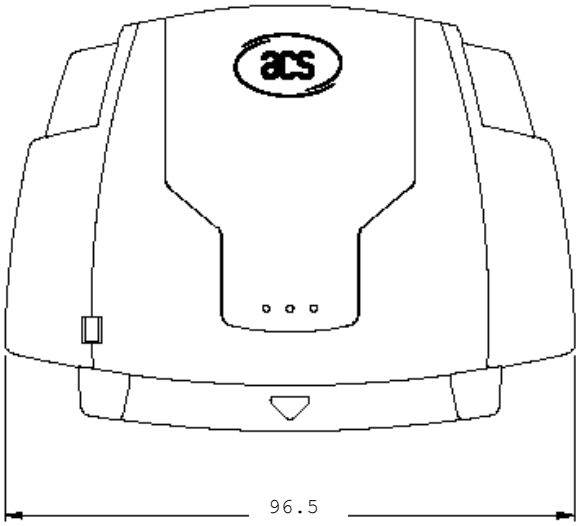
Card type code	Card Type
00_H	Auto-select T=0 or T=1 communication protocol
01_H	I2C memory card (1k, 2k, 4k, 8k and 16k bits)
02_H	I2C memory card (32k, 64k, 128k, 256k, 512k and 1024k bits)
03_H	Atmel AT88SC153 secure memory card
04_H	Atmel AT88SC1608 secure memory card
05_H	Infineon SLE4418 and SLE4428
06_H	Infineon SLE4432 and SLE4442
07_H	Infineon SLE4406, SLE4436 and SLE5536
08_H	Infineon SLE4404
09_H	Atmel AT88SC101, AT88SC102 and AT88SC1003
$0C_H$	MCU-based cards with T=0 communication protocol
$0D_H$	MCU-based cards with T=1 communication protocol

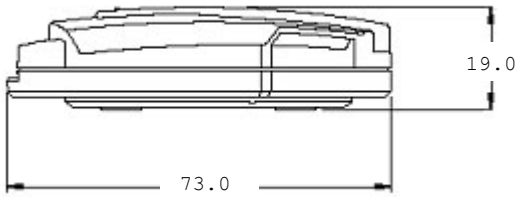
Appendix B. Response Error Codes

The following table summarizes the possible error code returned by the ACR38 CCID:

Error Code	Status
FF_h	SLOTERROR_CMD_ABORTED
FE_h	SLOTERROR_ICC_MUTE
FD_h	SLOTERROR_XFR_PARITY_ERROR
FC_h	SLOTERROR_XFR_OVERRUN
FB_h	SLOTERROR_HW_ERROR
$F8_h$	SLOTERROR_BAD_ATR_TS
$F7_h$	SLOTERROR_BAD_ATR_TCK
$F6_h$	SLOTERROR_ICC_PROTOCOL_NOT_SUPPORTED
$F5_h$	SLOTERROR_ICC_CLASS_NOT_SUPPORTED
$F4_h$	SLOTERROR_PROCEDURE_BYTE_CONFLICE
$F3_h$	**SLOTERROR_DEACTIVATED_PROTOCOL**
$F2_h$	SLOTERROR_BUSY_WITH_AUTO_SEQUENCE
$E0_h$	SLOTERROR_CMD_SLOT_BUSY

Appendix C. Technical Specifications





Universal Serial Bus Interface

Type .....USB full speed, four lines: +5V, GND, D+ and D-
Power source.....From USB
Speed.....12 Mbps

Smart Card Interface

Standard .....ISO-7816 Class A, B and C (5V, 3V, 1.8V), T=0 and T=1
Supply current .....max. 50mA
Smart card read / write speed.....1,953 – 344,086 bps
Short circuit protection .....+5V / GND on all pins
The presence of the smart card power supply voltage is indicated through a green LED on the reader
CLK frequency.....4 MHz
Card connector.....Contact
Card insertion cycles.....min. 100,000

Physical Specifications

Dimensions.....73.0mm (L) x 96.5mm (W) x 19.0mm (H)
Color .....Silver
Weight.....95g (± 5g allowance for cable) - Spaceship casing
Cable length, cord, connector.....1.5 meters, Fixed (non-detachable), USB A

Operating Conditions

Temperature .....0 - 50° C
Humidity.....40% - 80%

Certifications/Compliance

EN 60950/IEC 60950, RoHS Compliant, EMV 2000 Level 1, ISO-7816, PC/SC, CCID, FIPS201 Certified, CE, FCC
USB Full Speed, Microsoft WHQL 2000, XP, Vista

Device Driver Operating System Support

Windows ® 98, ME, 2000, XP, Vista, Server 2003,