M519 Data Sheet and Hardware Integration Guide

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00	07/11/2022	JDA		Draft preview
AA	16/08/2023	JDA	CFE	First public release (but still with a lot of *TBD*)

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1 Introduction

1.1 Overview

This document describes the functionalities and electrical specifications of the SpringCard SpringSeed M519 OEM NFC/RFID HF module, using firmware version 1.30 or higher.

1.2 Related Documents

1.2.1 Documents available as PDF

Reference	Title / Description
PMD17182	PC/SC Couplers Embedded APDU Processor
PMD15305	Zero-Driver CCID low level Implementation

1.2.2 Online Material

Documentation of the SpringCore firmware.

https://docs.springcard.com/books/SpringCore/Welcome

SpringCard Tech Zone, the blog of the R&D Team

https://tech.springcard.com/

1.3 Order codes

Order code	Model	MOQ
SC23076	M519 (cut reel)	50 units
SC23231	M519 (cut reel)	100 units
SC23218	M519, reel of 1000 units	1 reel (1000 units)

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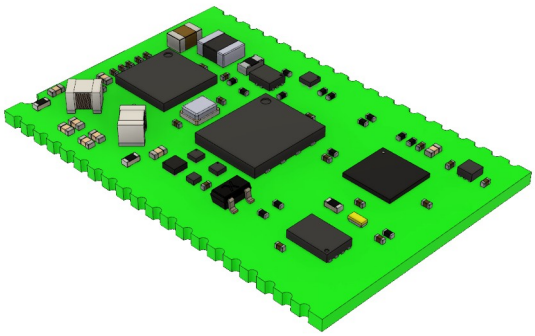
2 About the SpringSeed M519

2.1 General Description



The SpringCard SpringSeed M519 is a versatile OEM NFC/RFID HF module.

The M519 is designed to be used in industrial equipments or consumer devices, and has to be connected to an external antenna through a “mother board” PCB.

The M519 is able to communicate with virtually any contactless smart card, RFID label, NFC tag or NFC smartphone compliant with one of the standard technologies in the 13.56MHz range.

The M519 features a contact smart card interface, that is able to drive either one SAM card (ID-000) either directly or through a NXP TDA8035 IC, or to drive up to 5 ID-1 and ID-000 slots through a NXP TDA8026 IC.

The M519 also features a protected storage for secret and private cryptographic keys, and is able to run secure transactions protected by AES or ECC schemes with contactless cards and NFC smartphones.

The M519 is either a Serial device or a USB device; it operates either in Coupler mode (reader/writer, APDU level) or in Smart Reader mode, freeing the host from all technical aspects of the transaction with the cards.

The M519 may either be surface-mounted on its “mother board” PCD using the edge-plated pads, or be soldered on 0.50" (1.27mm) headers using Ø0.6 half-holes on the outline.

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2.2 Features and benefits

2.2.1 Ease of integration into any hardware

- Smallest design on the market (26.67 x 17.78 x 2.6 mm or 1.05 x 0.7 x 0x10 "),
- Components mounted on the top side only, bottom pads and castellated edges ready for either SMD or THT mounting,
- NXP PN5190 NFC/RFID HF frontend allowing best in-class performance/power ratio,
- Self-antenna tuning capability,
- Single-source power supply, power saving modes, low power card detection features on less than 5µA,
- ISO 7816 interface supporting up to 4 external SIM/SAM (ID-000) slots and 1 ID-1 smart card slot.

2.2.2 Ease of integration for any application and use case

- Serial interface supporting a various choice of protocols, making it easy to operate the module even from low-end MCUs,
- USB interface supported by Linux (even low-end embedded SOCs), Windows and macOS
- In-the-field configuration and firmware upgrade (flash) without interruption,
- Comprehensive starter kit and a wide range of SDK and samples available for free on GitHub,
- Compliant with earlier SpringCard SDKs and software libraries (PC/SC, SpringProx, etc).

2.2.3 Open and interoperable

- Standard-compliant USB CCID (PC/SC) and USB HID keyboard wedge (RFID Scanner) profiles,

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- Contactless stack validated against EMV CL L1 Digital, NFC Forum CR12 and CEN/TS 16794 (RCTIF) test suites,
- Contact stack validated against EMV CT L1 Digital test suite,
- Support of Apple Pay ECP1 and ECP2 for Passkit / Apple VAS applications, support of Google Smart Tap,
- Support of NXP Mifare and NTAG families, the largest portfolio of contactless cards.

2.3 Typical applications

- Public transport, public bike systems, car sharing,
- Car-park gates or cashiers,
- Kiosk, vending machines,
- Mobile or afixed terminals for loyalty, events, gaming...
- Access control, secure identification,
- and more.

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3 Technical Data

3.1 General

Dimensions	26.67 x 17.78 x 2.6 mm
Weight	Approx. 7g
Power supply	3.3V nominal for Serial operation 5V (powered by the bus) for USB operation
Power requirement	Nominal: 200mA Max: 400mA Power saving: < 1mA
Temperature range	Operating temperature: -20 to +70°C Storage temperature: -20 to +70°C
Environment	*TBD*

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3.2 NFC/RFID HF (contactless) Interface

3.2.1 Coupler and Smart Reader operation

NFC/RFID HF carrier	13.56MHz
Antenna requirement	External antenna, 20Ω-matched, balanced
Operating distance	Up to 100mm depending on antenna, card and environment
RF power	Max 2W
Supported standards	ISO/IEC 14443 A & B (PCD) / NFC-A and NFC-B ISO/IEC 15693 (VCD) and ISO/IEC 18000-3M1 / NFC-V ISO/IEC 18000-3M3 (RFID HF) / EPC HF JIS X 6319-4 / NFC-F ISO/IEC 21481 (NFCIP-2)
Bitrates	26, 53, 106, 212, 424, 848 kbit/s depending on the protocol
Supported card technologies (partial list)	NFC Forum types 1, 2, 3, 4 and 5 Mifare Classic with CRYPTO1 All cards in NXP Mifare families: Mifare Plus, Mifare UltraLight, Desfire, All cards in NXP NTAG and ICODE families Innovatron (Calypso cards) STMicroElectronics SR & LR Infineon SLE44, SLE66, SRF55 Texas Instrument Tag-it Sony FeliCa Lite Apple ECP, Apple VAS (PassKit NFC), Google Smart Tap and other NFC applications on smartphones Inside Secure PicoPass / HID iClass (ID only)
Advanced features	Low power card detection Automatic waveform control

3.2.2 Card emulation and peer-to-peer operation

Supported standards	ISO/IEC 14443 A (PICC) / emulation of NFC Forum Type 4A Tag ISO/IEC 18092 (NFCIP-1) active and passive, initiator and target
Bitrates	106, 212, 424 kbit/s depending on the protocol

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3.3 Smart card (contact) Interface

Card clock	4MHz
Card power class	Direct on M519: 3.3V (class B) Through TDA8026 or TDA8035: 1.8V, 3.3V or 5V (classes A, B, C)
Supported standards	ISO/IEC 7816-3, 7816-4
Bitrates	TA1=$_H$11 (10752bps) to TA1=$_H$97 (500kbps)

3.4 Host Interfaces

3.4.1 USB

Standard	USB 2.0 device, compatible with USB 3
Bitrate	Full speed (12Mbps)
Profiles	CCID (PC/SC) HID keyboard CDC-ACM (serial emulation) SpringCore Direct

3.4.2 Serial

Physical interface	RX/TX @ 0/3.3V (compliant with TTL & CMOS peers) 8 data bits, 1 stop bit, no parity, no flow control
Bitrate	38400bps (default), up to 500kbps after handshaking
Protocols	CCID over Serial SpringProx Legacy SpringCore Direct RDR MK1 $SCRDR

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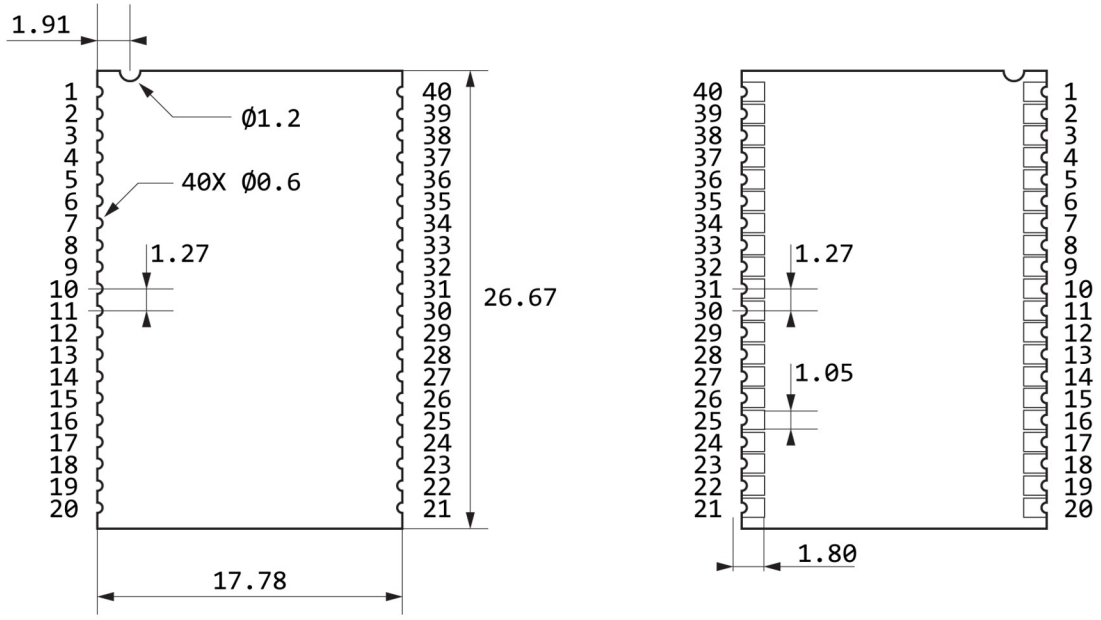
4 Mechanical Specification

4.1 Dimensions and location of the pins

The M519 is a single-sided PCB with dual castellated/through-hole pins around the edges. It is designed to be usable as a surface mount module as well as being in Dual Inline Package (DIP) type format, with the 40 main pins on a 1.27mm (0.05") pitch grid with 0.6mm holes.

A 1.2mm half-hole on the left-hand side of the north-bound edge acts as a *poka yoke* (polarizer) to let the pick and place machine know where pin #1 is.



ALL DIMENSIONS IN MILLIMETERS
PRINT VERSION NOT TO SCALE
(APPROX 2:1)
OUTLINE TOLERANCE ±0.25MM - TOLERANCE ON DRILLING Ø ±0.05MM
LOCATION OF PADS ACCORDING TO IPC-A-600 CLASS 2

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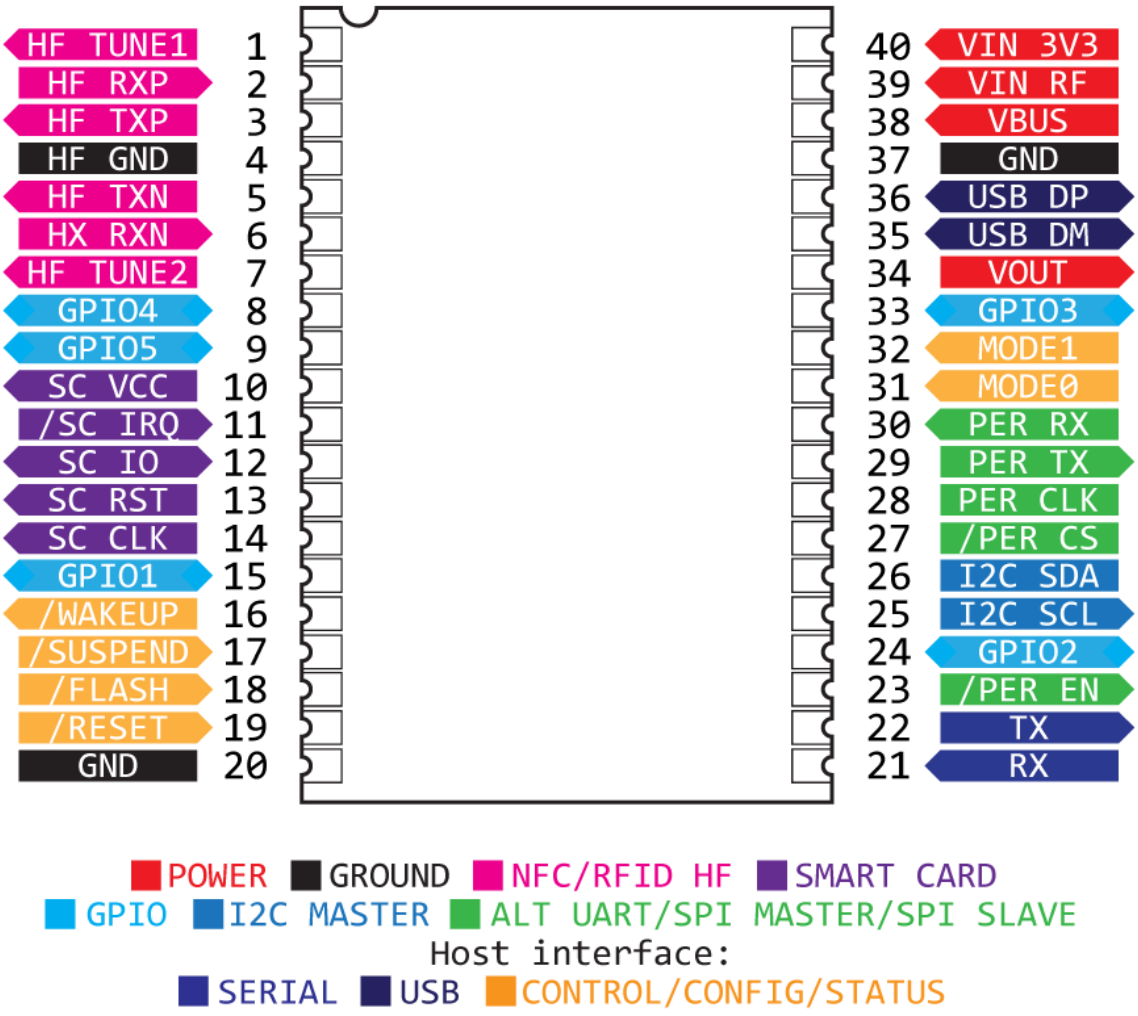
4.2 Pinout



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4.2.1 West-bound header

Pin	Symbol	Type	Description
# 1	**HF_TUNE1**	Analog	Antenna self-tuning capacitor 1
# 2	**HF_RXP**	Analog	Antenna receiver (plus side)
# 3	**HF_TXP**	Analog	Antenna driver (plus side)
# 4	**HF_GND**	Analog	Antenna ground
# 5	**HF_TXP**	Analog	Antenna driver (minus side)
# 6	**HF_RXN**	Analog	Antenna receiver (minus side)
# 7	**HF_TUNE2**	Analog	Antenna self-tuning capacitor 2
# 8	**GPIO4**	In/Out	
# 9	**GPIO5**	In/Out	
# 10	**SC_VCC**	Out	Card VCC signal
# 11	**/SC_IRQ**	In	Card status / TDA8026 interruption
# 12	**SC_IO**	In/Out	Card I/O signal
# 13	**SC_RST**	Out	Card RST signal
# 14	**SC_CLK**	Out	Card CLK signal (4MHz) / TDA8026 master clock (16MHz)
# 15	**GPIO1**	In/Out	
# 16	**/WAKEUP**	Out	Tell the host that the module is active
# 17	**/SUSPEND**	In	Tell the module to enter standby mode
# 18	**/FLASH**	In	Force DFU (bootloader) mode upon reset
# 19	**/RESET**	In	Reset the module
# 20	**GND**	Ground	

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4.2.2 East-bound header

Pin	Symbol	Type	Description
# 21	**RX**	In	Main UART, host to module
# 22	**TX**	Out	Main UART, module to host
# 23	**/PER_EN**	Out	Activate the peripherals
# 24	**GPIO2**	In/Out	
# 25	**I2C_SCL**	Out	I^2C SCL (master)
# 26	**I2C_SDA**	In/Out	I^2C SDA (master)
# 27	**/PER_CS**	In/Out	SPI chip select
# 28	**PER_CLK**	In/Out	SPI clock
# 29	**PER_TX**	Out	TX to peripherals
# 30	**PER_RX**	In	RX from peripherals
# 31	**MODE0**	In	Configure operating mode
# 32	**MODE1**	In	Configure operating mode
# 33	**GPIO3**	Out	
# 34	**VOUT**	Out	3.3V output, max 100mA, to power the peripherals
# 35	**USB_DM**	USB	USB D- signal
# 36	**USB_DP**	USB	USB D+ signal
# 37	**GND**	Ground	
# 38	**VBUS**	USB	Digital power supply + USB presence, 5V
# 39	**VIN_RF**	Power	Power supply for RF, either 3.3V or 5V
# 40	**VIN_3V3**	Power	Digital power supply 3.3V

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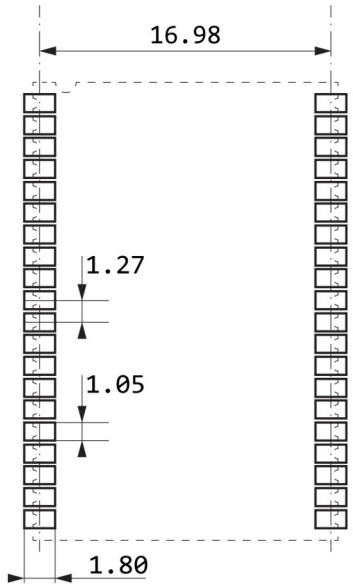
4.3 Recommended PCB layout

The following footprint is recommended for systems which will be reflow-soldering the M519 as a module.



RECOMMENDED PCB LAYOUT

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4.4 Tape and Reel Packaging

The M519 is delivered in Tape and Reel.

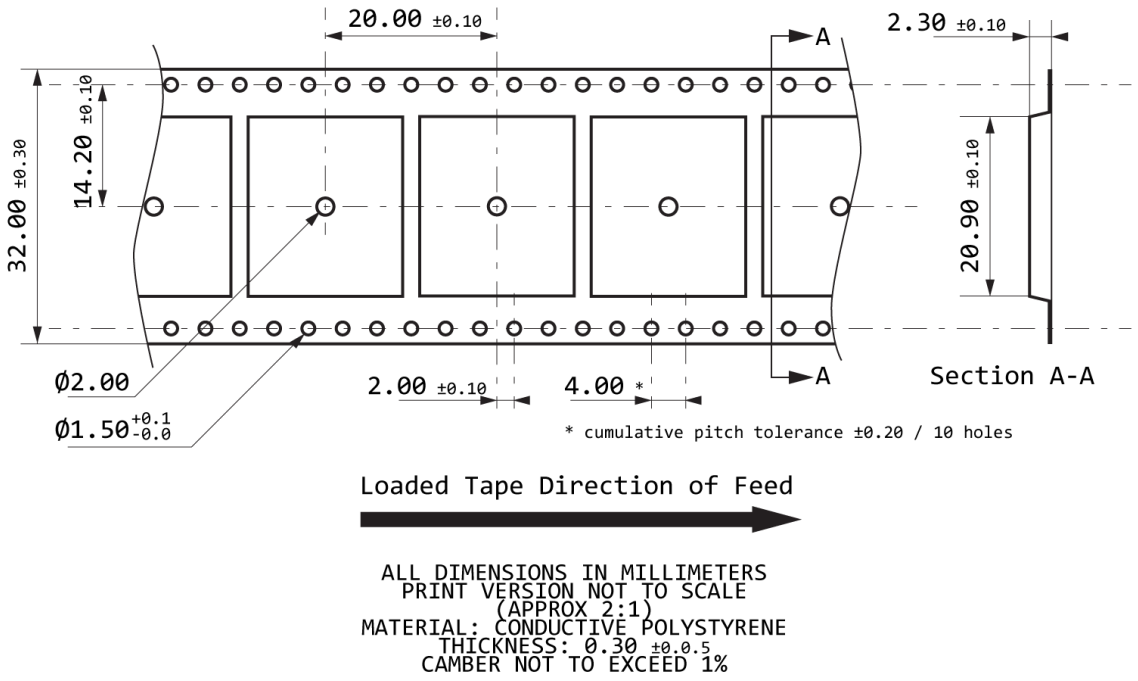

Figure 1: Tape specification

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5 Electrical Specification

5.1 Limiting values

Stresses beyond those listed under 'Limiting values' may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these conditions is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Symbol	Parameter	Conditions	Min	Max	Unit
VIN_3V3_{ABS}	Supply voltage on pin VIN_3V3		*TBD*	*TBD*	V
$VBUS_{ABS}$	Supply voltage on pin VBUS		*TBD*	*TBD*	V
VIN_RF_{ABS}	Supply voltage on pin VIN_RF		*TBD*	*TBD*	V
V_{ANA}	Voltage on any analog pin		*TBD*	*TBD*	V
V_{DIG}	Voltage on any digital pin		*TBD*	*TBD*	V
V_{ESD}	Electrostatic discharge voltage		-500	500	V
$T_{JUNCTION}$	Junction temperature		—	+120	°C
$T_{STORAGE}$	Storage temperature	No voltage applied	-20	+70	°C

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5.2 Power

5.2.1 Power supply voltage

5.2.1.1 USB operation

Symbol	Parameter	Min	Typical	Max	Unit
VBUS	Digital supply voltage, USB	4.5	5.0	5.5	V
VIN_RF_{VBUS}	RF supply voltage, USB	3.0	5.0	5.5	V

Pin # 40 VIN_3V3 shall be left unconnected for USB operation.

5.2.1.2 Serial operation

Symbol	Parameter	Min	Typical	Max	Unit
VIN_3V3	Digital supply voltage, Serial	3.0	3.3	3.6	V
VIN_RF_{3V3}	RF supply voltage, Serial	3.0	3.3	4.5	V

Pin # 38 VBUS shall be left unconnected for Serial operation.

5.2.2 Current consumption

5.2.2.1 USB operation

Symbol	Parameter / Conditions	Min	Typical	Max	Unit
$I_{VBUS,UNLOADED}$	Digital power supply, USB, no power drain on VOUT, no smart card	*TBD*	*TBD*	*TBD*	mA
$I_{VBUS,LOADED}$	Digital power supply, USB, 100mA power drain on VOUT, smart card VCC active	*TBD*	*TBD*	*TBD*	mA
$I_{VIN\_RF,USB}$	RF power supply, USB	*TBD*	*TBD*	*TBD*	mA

5.2.2.2 Serial operation

Symbol	Parameter / Conditions	Min	Typical	Max	Unit
$I_{3V3,UNLOADED}$	Digital power supply, Serial, no power drain on	*TBD*	*TBD*	*TBD*	mA

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	VOUT, no smart card				
$I_{3V3,LOADED}$	Digital power supply, Serial, 100mA power drain on VOUT, smart card VCC active	*TBD*	*TBD*	*TBD*	mA
$I_{VIN\_RF,3V3}$	RF power supply, Serial	*TBD*	*TBD*	*TBD*	mA

5.3 VOUT pin

Symbol	Parameter	Min	Typical	Max	Unit
VOUT	Peripheral(s) power supply voltage	3.0	3.3	3.6	V
I_{VOUT}	Peripheral(s) power supply current	—	—	100	mA

5.4 /RESET, /SUSPEND, /SC_IRQ pins

These digital input pins have permanent internal pull-up resistors.

Symbol	Parameter	Min	Typical	Max	Unit
V_{IL}	Low level input voltage	$V_{DIG,MIN}$	—	1.0	V
V_{IH}	High level input voltage	2.4	—	$V_{DIG,MAX}$	V
I_{IL}	Low level input leakage current	55	80	165	µA
I_{IH}	High level input leakage current	-1	±0.01	1	µA

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5.5 /FLASH, MODE0, MODE1 pins

These digital input pins have internal pull-up resistors that are enabled at boot time, but disabled once the firmware is running.

Symbol	Parameter	Min	Typical	Max	Unit
V_{IL}	Low level input voltage	$V_{DIG,MIN}$	—	1.0	V
V_{IH}	High level input voltage	2.4	—	$V_{DIG,MAX}$	V
I_{IL}	Low level input leakage current	55	0.1	165	µA
I_{IH}	High level input leakage current	-1	±0.01	1	µA

5.6 RX, PER_RX pins

These digital input pins have no internal pull-up resistors.

Symbol	Parameter	Min	Typical	Max	Unit
V_{IL}	Low level input voltage	$V_{DIG,MIN}$	—	1.0	V
V_{IH}	High level input voltage	2.4	—	$V_{DIG,MAX}$	V
I_{IL}	Low level input leakage current	-1	±0.01	1	µA
I_{IH}	High level input leakage current	-1	±0.01	1	µA

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5.7 TX, PER_TX, /PER_EN, /WAKEUP, SC_RST, SC_CLK, SC_VCC, I2C_SCL pins

These are digital output pins.

Symbol	Parameter	Conditions	Min	Typical	Max	Unit
V_{OL}	Low level output voltage	I_{OL}=1mA	0	0.3	0.6	V
V_{OH}	High level output voltage	I_{OL}=1mA	2.7	3.0	3.3	V
I_{OL}	Low level output current		—	—	2	mA
I_{OH}	High level output current		—	—	2	mA
SR_{SC_VCC}	Up or down transition time		—	—	0.04	µs

5.8 SC_IO, /PER_CS, PER_CLK, I2C_SDA pins

These pins are digital input and output; when used as input, they have no internal pull-up resistors.

5.8.1 As input

Symbol	Parameter	Min	Typical	Max	Unit
V_{IL}	Low level input voltage	$V_{DIG,MIN}$	—	1.0	V
V_{IH}	High level input voltage	2.4	—	$V_{DIG,MAX}$	V
I_{IL}	Low level input leakage current	-1	±0.01	1	µA
I_{IH}	High level input leakage current	-1	±0.01	1	µA

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5.8.2 As output

Symbol	Parameter	Conditions	Min	Typical	Max	Unit
V_{OL}	Low level output voltage	I_{OL}=1mA	0	0.3	0.6	V
V_{OH}	High level output voltage	I_{OL}=1mA	2.7	3.0	3.3	V
I_{OL}	Low level output current		—	—	2	mA
I_{OH}	High level output current		—	—	2	mA
SR_{SC_VCC}	Up or down transition time		—	—	0.04	µs

5.9 GPIO1, GPIO2, GPIO3, GPIO4, GPIO5 pins

These pins are digital input and output; when used as input, they do have internal pull-up resistors.

5.9.1 As input

Symbol	Parameter	Min	Typical	Max	Unit
V_{IL}	Low level input voltage	$V_{DIG,MIN}$	—	1.0	V
V_{IH}	High level input voltage	2.4	—	$V_{DIG,MAX}$	V
I_{IL}	Low level input leakage current	55	80	165	µA
I_{IH}	High level input leakage current	-1	±0.01	1	µA

5.9.2 As output

Symbol	Parameter	Conditions	Min	Typical	Max	Unit
V_{OL}	Low level output voltage	I_{OL}=1mA	0	0.3	0.6	V
V_{OH}	High level output voltage	I_{OL}=1mA	2.7	3.0	3.3	V
I_{OL}	Low level output current		—	—	2	mA
I_{OH}	High level output current		—	—	2	mA
SR_{SC_VCC}	Up or down transition time		—	—	0.04	µs

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6 Application Information

6.1 Operating modes, profiles and protocols

The M519 is a versatile module, based on the SpringCard SpringCore firmware, that supports many operating modes. Every operating mode is associated to one or more USB profile and Serial communication protocol. The choice of the operating mode and of the host interface is done upon reset (see § 6.3).

The paragraphs below summarizes the options and explains the basics; for a complete reference, please read the documentation of the SpringCore firmware:

https://docs.springcard.com/books/SpringCore/Introduction/Operating_Modes

6.1.1 PC/SC Coupler mode

In this mode, the M519 is a complete smart card coupler: it can perform any transaction with a smart card, under full control of an application running in the host computer.

The smart card may be either contact or contactless (NFC/RFID) depending on only on its hardware interface, but operated the same way seen from the software interface.

As a PC/SC device, the M519 is typically associated to a PC/SC driver and is supported by the computer's PC/SC stack.

The PC/SC Coupler mode is selected by writing $_{H}$02 into configuration register $_{H}$02C0, or by driving MODE0=HIGH, MODE1=LOW on reset.

6.1.1.1 USB

When the PC/SC Coupler mode is selected and the host interface is USB, the M519 is a compound device that exposes both the CCID profile and the SpringCore Direct profile *(more on the Direct profile in § 6.1.3)*.

The CCID profile of the M519 is fully supported by the open-source CCID driver available on Linux together with the PC/SC-Lite stack, and by the CCID driver and PC/SC stack

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provided by Apple for macOS. For Microsoft Windows, SpringCard driver SD16055 shall be used[1].

6.1.1.2 Serial

When the PC/SC Coupler mode is selected and the host interface is Serial, the M519 uses the CCID over Serial protocol.

See Application Note PNA23174 “Using the M519 in PC/SC Coupler mode over a Serial interface” for reference.

6.1.2 Smart Reader mode

In this mode, the M519 is an autonomous or NFC/RFID reader.

It automatically grabs a token from a contactless cards, NFC tags or RFID labels, before transmitting it to the host. This simplifies the development of the host application, because the M519 runs the transaction with the card, tag or label in a standalone-reader approach.

This also makes it possible to use a fast anticollision/inventory scheme, overriding the bottleneck introduced by a slow computer-based transaction or a too complex driver stack.

The Smart Reader mode is selected by writing $_{H}$03 into configuration register $_{H}$02C0, or by driving MODE0=LOW, MODE1=HIGH on reset.

6.1.2.1 USB

When the Smart Reader mode is selected and the host interface is USB, the M519 is a compound device that exposes both the HID keyboard profile and the SpringCore Direct profile *(more on the Direct profile in § 6.1.3)*.

Thanks to the standard HID keyboard profile, the M519 is automatically recognized as a keyboard by all the major operating systems that support USB (Windows, macOS, Linux, Android, iOS…), and the data collected from NFC/RFID tags are automatically received as key-strokes in the active application. SpringCard calls this feature “RFID Scanner”.

1 Microsoft also provides a CCID driver that works fine with the M519, but unfortunately this driver is single-slot only. Using SpringCard driver instead adds multi-slot support and simplifies the development.

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For correct operation, the user must configure the M519 with the same keyboard layout as the host system.

6.1.2.2 Serial

When the Smart Reader mode is selected and the host interface is Serial, the M519 sends the data collected from NFC/RFID tags over its serial line, using the protocol selected in configuration register $_H$02A0.

- **$SCRDR protocol** (default): data come as ASCII strings, starting with constant value “$SCRDR”.

Format specification:

```
$SCRDR;<Interface>;<Protocol>;<Template>;<RSSI>;<TagId>;<Move>;<TagData>;<TagDetails>*<Checksum><CR><LF>
```

Example:

```
$SCRDR;13.56;NFC-A;1;;047DAE02C84080;;00047DAE02C84080;*47<CR><LF>
```

- **MK1 protocol**: this is a legacy protocol, taken from earlier SpringCard devices, that provides only the TagId. The $SCRDR protocol shall be preferred.

Example:

```
+047DAE02C84080<CR><LF>
```

- **JSON protocol**: data is encapsulated in a JSON object.

Example:

```
{
      "Interface":"13.56",
      "Protocol":"NFC-A",
      "Template":1,
      "TagId":"047DAE02C84080",
      "TagData":"00047DAE02C84080",
      "Uptime":"699:16.850"
}
```

- **TLV protocol**: data object uses ASN.1 binary encoding rule.

Example:

```
B0 0E C1 04 00 03 01 01 C2 07 04 7D AE 02 C8 40 80
```

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6.1.3 Direct protocol and fail-safe mode

SpringCore Direct is a proprietary protocol for new SpringCard devices that allows to flash, configure and use a device with more flexibility and faster that other protocols.

Most SpringCard software, like the SpringCore Tools and SpringCard Companion, rely on the SpringCore Direct protocol to access the devices in a seamless way, whatever their host interface and operating modes are. This protocol also allows an application to have full control over the reader, for advanced Smart Reader operation.

In the M519, the Direct protocol is associated to a fail-safe mode: the device bypass all configuration settings that may disable an interface or prevent communication, and disables most power sinks, to help debugging or fine-tuning the system.

The SpringCore Direct protocol and the fail-safe mode are selected by writing $_H$00 into configuration register $_H$02C0, or by driving MODE0=LOW, MODE1=LOW on reset.

6.1.4 SpringProx Legacy

SpringProx Legacy is the proprietary protocol and mode of operation introduced in the 2000s with the first generation of SpringCard devices. PC/SC Coupler mode and the CCID protocol shall be preferred when designing a new system.

It must be understood by the developer/implementer that the M519 is not a drop-in replacement for earlier K531, K632, K663, CSB4. The high-level behaviour is the same, but low-level control of the RF interface has to be rewritten.

The SpringProx Legacy mode and protocol are selected by writing $_H$01 into configuration register $_H$02C0.

6.1.4.1 USB

When the SpringProx Legacy is selected and the host interface is USB, the M519 uses the USB CDC ACM profile (communication device class, abstract control model). It is automatically recognized as a (virtual) communication port by all the major desktop operating systems (Windows, macOS, Linux...). The M519 accepts SpringProx Binary and ASCII messages (not OSI3964) and it is possible to use the `springprox.dll` over this (virtual) communication port without a change.

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6.1.4.2 Serial

When the SpringProx Legacy is selected and the host interface is Serial, the M519 accepts SpringProx Binary and ASCII messages (not OSI3964) and it is possible to use the `springprox.dll` without a change.

6.2 Bootloader, firmware upgrade

The M519 features a bootloader that allows to change its firmware. There are two ways to perform the upgrade: in-the-field, over a live system (Live upgrade) or after having explicitly activated the bootloader.

6.2.1 Live upgrade

The typical firmware upgrade procedure is:

- A new firmware is transmitted using the Direct protocol while the M519 is operating “normally” (this new firmware is written in a temporary storage area),
- When the M519 resets, its bootloader copies the new firmware from the storage area to the ROM of the microcontroller,
- The M519 resets again, running its new firmware.

When the Live upgrade procedure is used, the user application does not need to activate the bootloader explicitly, nor to communicate with the bootloader.

When the host uses the USB interface, Live upgrade is always possible because the Direct protocol is always available, at least as a secondary profile (compound device).

To perform the upgrade over USB, use either:

- SpringCoreFlash, a command line tool (member of the SpringCore Tools suite) that is easy to deploy and run unattended

  https://www.springcard.com/fr/download/find/file/sq20029

- SpringCard Companion, a web application + local service, for a more user-friendly experience.

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https://companion.springcard.com

6.2.2 Bootloader upgrade

Live upgrade is not possible when the host uses the Serial interface and the configuration does not enforce Direct protocol, fail-safe mode.

In this case, the host must explicitly restart the M519 in bootloader mode, and write the new firmware directly in the ROM of the microcontroller through the bootloader.

The bootloader is activated by driving /FLASH=LOW on reset or by sending command `flash<CR><LF>` through the shell (§ 6.4).

The bootloader uses a simplified implementation of the Direct protocol, where only the DFU class (Device Firmware Upgrade) is available:

https://docs.springcard.com/books/SpringCore/Host_Protocols/Direct_Protocol/DFU_class/index

Once the bootloader has been activated, you may also use SpringCoreFlash to perform the upgrade over either the USB or the Serial interface.

6.3 Reset configuration and MODE0, MODE1 pins

When the M519 is powered-up or its /RESET pin is risen (Low to High transition), the module resets and probes VIN3_V3, VBUS, /FLASH, MODE0 and MODE1.

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The reset configuration defines:

1. whether the host interface is the serial line or the USB bus,

VBUS	VIN_3V3	Host interface
5V	—	USB
unconnected	**3.3V**	Serial

Do not connect anything to VBUS unless you want to activate USB.

2. whether the M519 activates its main firmware or stays in bootloader mode,

/FLASH	Firmware activation
LOW	M519 runs its bootloader
HIGH	M519 runs its firmware

You may leave the /FLASH pin unconnected if your application does not need to activate the bootloader.

3. when the main firmware is activated, which operating mode shall be selected.

MODE0	MODE1	Operating mode
HIGH	**HIGH**	As set in non-volatile memory (configuration register $_{H}$02C0)
HIGH	**LOW**	PC/SC Coupler
LOW	**HIGH**	Smart Reader
LOW	**LOW**	SpringCore Direct, fail-safe mode

You may leave the MODE0 and MODE1 pins unconnected if your application does not need to change the mode.

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The table below summarizes all the supported reset configurations and the associated USB profiles or Serial protocol:

VBUS	VIN_3V3	/FLASH	MODE0	MODE1	Interface	Operating mode	Profile/Protocol
5V	—	LOW	—	—	USB	Bootloader	Direct (DFU)
5V	—	HIGH	HIGH	HIGH	USB	Set by configuration register $_H$02C0	
5V	—	HIGH	HIGH	LOW	USB	PC/SC Coupler	CCID+Direct
5V	—	HIGH	LOW	HIGH	USB	RFID Scanner	HID keyboard+Direct
5V	—	HIGH	LOW	LOW	USB	Direct, fail-safe	Direct
N/C	3.3V	LOW	—	—	Serial	Bootloader	Direct (DFU)
N/C	3.3V	HIGH	HIGH	HIGH	Serial	Set by configuration register $_H$02C0	
N/C	3.3V	HIGH	HIGH	LOW	Serial	PC/SC Coupler	CCID+Console
N/C	3.3V	HIGH	LOW	HIGH	Serial	Smart Reader	$SCRDR+Console
N/C	3.3V	HIGH	LOW	LOW	Serial	Direct, fail-safe	Direct+Console

6.4 Serial shell

The M519 features a “human console” shell, that is available over its Serial interface

- whatever the operating mode,
- whether the host interface is Serial or USB.

The shell is namely used to explore or fine-tune the M519, or debug the system.

The communication parameters are:

- Baudrate: 38400bps,
- Format: 8 data bits, 1 stop bit, no parity, no flow control.

Note that if the shell is always enabled with these parameters when the device resets, it is generally disabled once the host has activated another protocol or changed the communication parameters. Always reset the device before trying to use the shell.

Send *<CR><LF>* to get the prompt of the device, that exposes its version and current operating mode.

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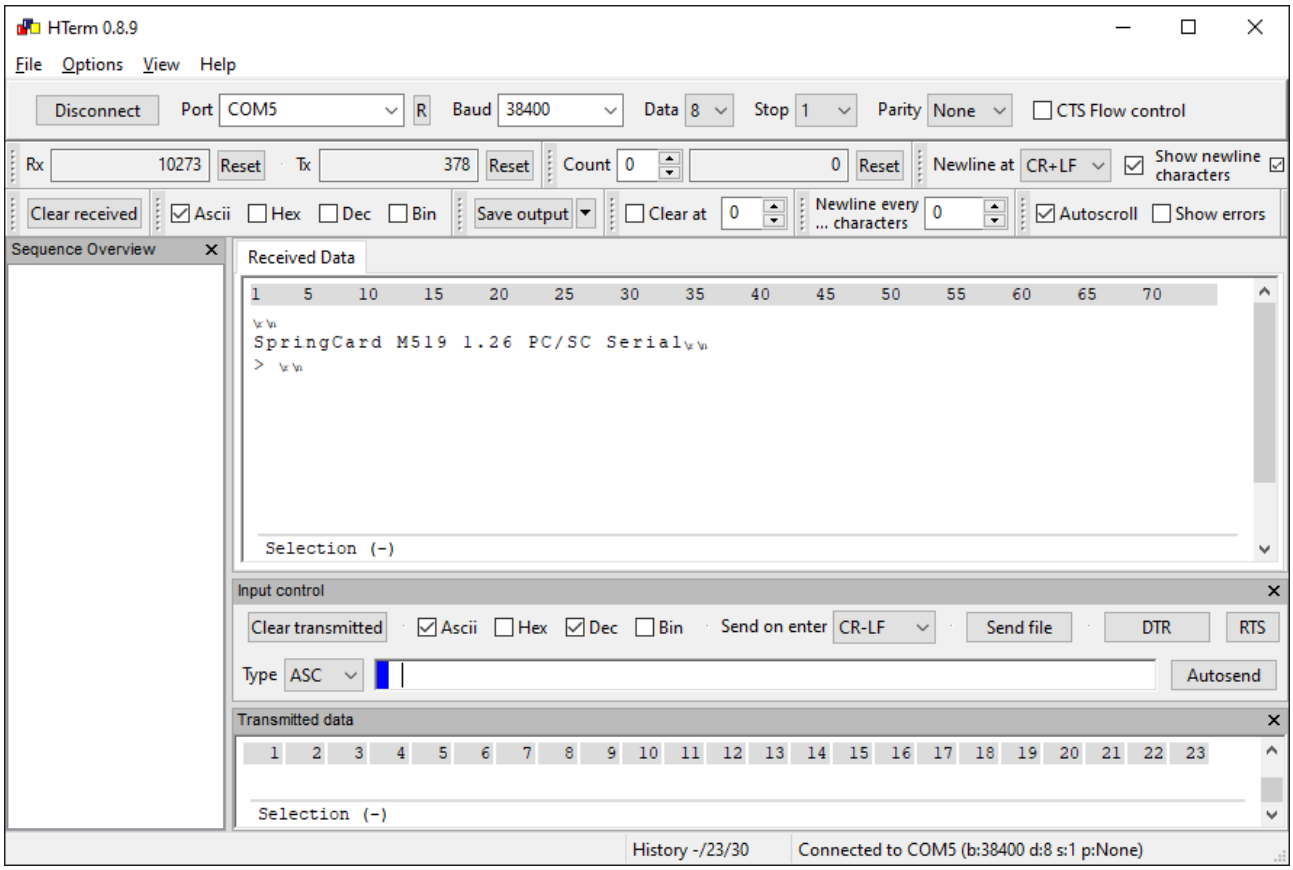

In the snapshot above,

- "v1.26" is the version number of the firmware. Newer firmwares will show another version number,
- "PC/SC" is the operating mode. Other possible values are "Direct", "SmartReader", "RFIDScan" and "Legacy",
- "Serial" is the primary host interface. Other possible value is "USB".

Enter `help<CR><LF>` to read the list of available commands.

6.5 Configuring the M519

The M519 is highly configurable. A new configuration may be written by a software provided by SpringCard, by the host application itself, or may be transmitted by the mean of a master card. When exploring/evaluating the M519, it is also possible to edit the configuration with the shell.

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Warning: writing an invalid configuration may disable the host interface(s) and prevent any communication with the device.

6.5.1 SpringCard configuration software

When the host uses the USB interface, in-the-field, Live configuration by SpringCard-provided software is always possible, because the Direct protocol is always available (at least as a secondary profile in the compound device).

To write a new configuration over USB, use either:

- SpringCoreConfig, a command line tool (member of the SpringCore Tools suite) that is easy to deploy and run unattended

  https://www.springcard.com/fr/download/find/file/sq20029

- SpringCard Companion, a web application + local service, for a more user-friendly experience.

  https://companion.springcard.com

6.5.2 Configuration by the host application

The CONTROL class of the Direct protocol, that is also available through the SCardControl function of the PC/SC Coupler mode, let the host application configure the M519.

For reference, please read:

https://docs.springcard.com/books/SpringCore/Host_Protocols/Direct_Protocol/CONTROL_class/index

6.5.3 Configuration through master cards

This feature is not yet implemented in the current version of the firmware.

6.5.4 Configuration by shell commands

In the Serial shell (§ 6.4),

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- Send command `cfg<CR><LF>` to read the current configuration,
- Send command `cfgXX=YYYY<CR><LF>` to write value $_{H}$YYYY in configuration register H02XX,
- Send command `cfgXX=<CR><LF>` to erase configuration register $_{H}$02XX (the default value will apply).

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7 Integration Guide – Host Interface

7.1 USB

TBD

7.2 Serial

TBD

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8 Integration Guide – RF antenna

TBD

8.1 Configuring the M519 for the actual antenna

Different antenna have a different impedance and different RF characteristics. The PN5190 NFC/RFID HF frontend IC in the M519 must be configured, in order to adapt its behaviour to the very antenna that it is driving.

The settings for the three compliant antennas developed by SpringCard are stored in the firmware of the M519:

- 69x45mm balanced antenna (basis of M519-SUV product, and ANT-S6945 in the M519-SRK),
- 25x25mm balanced antenna (ANT-S2525 in the M519-SRK),
- 80x80mm balanced antenna (ANT-S8080 in the M519-SRK).

When the M519 is delivered, the settings for the 69x45mm balanced antenna are selected.

Therefore, the integrator must explicitely activate different settings if a different antenna is used in the final design.

Warning: Using the M519 with an antenna that is not coherent with the settings of the PN5190:
- breaks compliance with ISO/IEC 14443 and 15693 and give an inconsistent operating range
- is likely to break CE/FCC conformity as well
- causes overheating of the module, of the antenna and/or of the matching circuit.

8.1.1 Using pre-stored antenna settings

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8.1.2 Using custom antenna settings

If you are developing a custom antenna, contact SpringCard Sales team, and have our experts validate your antenna and create the RF settings that your manufacturing system or software solution must inject into the M519 for correct operation with your antenna.

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9 Integration Guide – Contact smart card

The M519 features a smart card interface on its pin 10 to 14. The firmware is developed to be compliant with ISO/IEC 7816-3 at protocol level (T=0 and T=1), and with EMV Contact specification for the L1 digital part[2].

To be fully compliant with these standards (ISO/IEC 7816-3 electrical part, EMV Contact for the L1 analog part), a suitable physical smart card interface must be added to the design.

The M519 supports two different ICs to implement the smart card hardware:

- The NXP TDA8035, a single-slot smart card interface IC, that can drive one SIM/SAM card. See § 9.2 for reference on using the M519 with a TDA8035.
- The NXP TDA8026, a multiple-slot smart card interface IC, that can drive up to five cards. See § 9.3 for reference on using the M519 with a TDA8026.

TDA8035 and TDA8026 offer full compliance with the standards and cover all the power classes for the smart cards: class A (5V), class B (3.3V) and class C (1.8V). They implement ESD protections that are required for any system where the user may insert or remove the smart card.

For systems where the smart card is affixed to the PCB (typically when the “smart card” is a secure element in the form of an SMD IC and not actually a card), ESD protections and the support of many power levels are not mandatory. In this situation, it is possible to connect the “smart card” directly to the pins of the M519. See § 9.1 for reference on this use case.

2 The M519 being an OEM device, actual compliance with the standard and specifications is not asserted. Compliance tests and complete certifications could be performed on a “final”, assembled product only.

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9.1 Single slot, direct access

9.1.1 Overview

It is possible to connect a smart card directly to the M519, without any physical smart card interface IC, provided that the smart card operates at 3.3V and no ESD protection is required. Use this design to add an SMD secure element to your product with no extra costs.

9.1.2 Guidelines

The direct access smart card interface is implemented as follow:

- Connect /SC_IRQ to Ground,
- Connect SC_IO to the IO signal on the smart card,
- Connect SC_CLK to the CLK signal on the smart card (the M519 provides a 4MHz clock),
- Connect SC_RST to the RST signal on the smart card,
- Use SC_VCC to control the smart card power (voltage is up when SC_VCC is high). You may use VOUT as power source.

9.1.3 Reference schematics

TBD

9.1.4 Firmware implementation / PC/SC slot

Internally, the single slot is slot #1 (#0 is not used). Use this page to configure it:

https://docs.springcard.com/books/SpringCore/Non_volatile_memory/Configuration/Smartcards/First_ID_000_slot

(Of course, the power class settings is ignored in this design, since the hardware is limited to 3.3V only)

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On the PC/SC interface, the slot is named “M519 SAM” (without a letter, unless the letter is enforced by configuration).

9.1.5 Card tracking

This design does not provide card tracking (the M519 has no way to be notified if the card is inserted or removed). Make sure that the card is already present when the M519 starts, and remains present all the time.

9.2 Single ID-000 slot, using TDA8035

9.2.1 Overview

NXP TDA8035 is a low-power, single-slot analog smart card interface. It is the best solution to associate one ID-000 slot to the M519, when the product being designed must support one SIM/SAM card (typically for public transport or closed-loop payment applications).

For details, please consult the data sheet at NXP’s:

https://www.nxp.com/products/security-and-authentication/contact-readers/high-integrated-and-low-power-smart-card-interface:TDA8035HN

9.2.2 Guidelines

The TDA8035 is normally driven by I/O signals, but to limit the number of signal lines between the M519 and the board with the ID-000 slot, the TDA8035 has to be associated to a 4-bit I^2C I/O expander (NXP PCA9536, I^2C address $_H41$). The PCA9536DP also let the M519 detect the presence of the slot.

This interface is implemented as follow:

- Connect /SC_IRQ to OFFn on the TDA8035,
- Connect SC_IO to IOUC on the TDA8035,

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- Connect SC_CLK to X1 on the TDA8035 (the M519 provides a 4MHz clock), leave X2 unconnected, set CDIV1 and CDIV2 to select a 1:1 clock divider,
- Connect SC_RST to RST on the TDA8035,
- Leave SC_VCC unconnected (the M519 will drive the VCC signal of the card through I^2C only; respect exactly the reference schematics in § 9.2.3 to connect the PCA9536 and the TDA8035 correctly),
- Use VOUT to power the PCA9536 and the digital part of the TDA8035; its analog part may be powered by another source.

9.2.3 Reference schematics

TBD

9.2.4 Firmware implementation / PC/SC slot

Internally, the single slot is slot #1 (#0 is not used). Use this page to configure it:

https://docs.springcard.com/books/SpringCore/Non_volatile_memory/Configuration/Smartcards/First_ID_000_slot

On the PC/SC interface, the slot is named “M519 SAM” (without a letter, unless the letter is enforced by configuration).

9.2.5 Card tracking

Thanks to the OFFn signal of the TDA8035 connected to /SC_IRQ, the M519 is notified of card insertion or removal. This let the M519 report the actual card status to the application.

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9.3 One ID-1 and four ID-000 slots, using TDA8026

9.3.1 Overview

NXP TDA8026 is an analog interface for addressing multiple smart card slots from a single controller. It is the best solution to add to associate four ID-000 slot to the M519, when the product being designed must support a few SIM/SAM cards (typically for public transport applications with more than one network instance) and/or support one ID-1 slot for “full-size” smart cards (typically for card issuing applications or card printers).

For details, please consult the data sheet at NXP’s:

https://www.nxp.com/products/security-and-authentication/contact-readers/multiple-smart-card-slot-interface:TDA8026ET

9.3.2 Guidelines

The TDA8026 is driven by I^2C. Its addresses must be $_H22$, $_H23$ and $_H26$.

This interface is implemented as follow:

- Connect /SC_IRQ to IRQn on the TDA8026,
- Connect SC_IO to IOUC1 and IOUC2 on the TDA8026,
- Connect SC_CLK to CLKIN1 and CLKIN2 on the TDA8026 (the M519 provides a 16MHz clock[3]), leave X2 unconnected, set CDIV1 and CDIV2 to select a 1:1 clock divider,
- Connect SC_RST to SDWNN on the TDA8026 (the M519 will drive the RST signal of the card through I^2C only),
- Leave SC_VCC unconnected (the M519 will drive the VCC signal of the card through I^2C only),
- Use VOUT to power the PCA9536 and the digital part of the TDA8026; its analog part may be powered by another source.

3 The smart cards will be clocked at 4MHz. Using an input clock at 16MHz associated to a 1:4 divider is required for EMV compliance (using a 4MHz clock with a 1:1 divider is OK for ISO but not for EMV).

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9.3.3 Reference schematics

TBD

9.3.4 Firmware implementation / PC/SC slots

9.3.4.1 ID-1 slot

Slot #0 as seen from the firmware is the ID-1 slot. Use this page to configure it:

https://docs.springcard.com/books/SpringCore/Non_volatile_memory/Configuration/Smartcards/Main_slot

On the PC/SC interface, this slot is named “M519 Contact”.

9.3.4.2 ID-000 slot A

Slot #1 as seen from the firmware is the first ID-000 slot. Use this page to configure it:

https://docs.springcard.com/books/SpringCore/Non_volatile_memory/Configuration/Smartcards/First_ID_000_slot

On the PC/SC interface, this slot is named “M519 SAM A”.

9.3.4.3 ID-000 slots B, C, D

Slot #2, #3 and #4 as seen from the firmware are the next ID-000 slots. They are configured globally:

https://docs.springcard.com/books/SpringCore/Non_volatile_memory/Configuration/Smartcards/Other_ID_000_slots

On the PC/SC interface, these slots are named “M519 SAM B”, “M519 SAM C” and “M519 SAM D” respectively.

9.3.5 Card tracking

The M519 is notified by the TDA8026 of card insertion or removal in the slot #0 (“M519 Contact”) or in the slot #1 (“M519 SAM A”). This let the M519 report the actual card status to the application.

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On the other hand, slots #2, #3 and #4 (“M519 SAM B”, “M519 SAM C” and “M519 SAM D” have no tracking system, and the M519 is not notified when the card is inserted or removed. Make sure, when designing the final product, that the M519 and the TDA8026 are powered off when the user open the shell to access these slots.

9.3.6 Disabling unmounted/unused slots

When the M519 detects that it has a TDA8026 as peripheral on its I^2C bus, the module assumes that it has five slots (one ID-1 and four ID-000). This is not always the case: the final design may have only one ID-1 and one ID-000, or four ID-000 and no ID-1, or even one ID-1 only.

In this situation, it is advised to let the module disable the slots that are actually not wired. There are two ways to do so: by adding some hardware, or by configuration.

9.3.6.1 Hardware

Add a NXP PCA9536 to the design (4-bit I^2C I/O expander, I^2C address $_H41$). If both a TDA8026 and a PCA9536 are present, the M519 implements the following rules:

- IO0 on PCA9536 tied to a LOW level → slot #0 (ID-1, “M519 Contact”) is removed.
- IO1 on PCA9536 tied to a LOW level → slot #1 (ID-000, “M519 SAM A”) is removed.
- IO2 on PCA9536 tied to a LOW level → slots #2, #3 and #4 (ID-000, “M519 SAM B”, “M519 SAM C” and “M519 SAM D”) are removed.
- IO3 on PCA9536 tied to a LOW level → slot #1 is ID-1, not ID-000 (slot #1 is “M519 Contact B”; slot #0 becomes “M519 Contact A”, slot #2 becomes “M519 SAM A”, etc).

9.3.6.2 Configuration

When the M519 is configured for PC/SC mode, use this configuration register to manage the list of slots:

https://docs.springcard.com/books/SpringCore/Non_volatile_memory/Configuration/PC_SC/Slot_listing

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9.4 Smart card interface detection algorithm

When starting-up, the M519 uses the following algorithm to detect the smart card interface:

- If /SC_IRQ is asserted (LOW level) at startup, then the presence of a smart card in direct connection is assumed (§ 9.1).
- If a NXP TDA8026 is found on the I^2C bus, then this interface is activated (§ 9.3). SC_CLK is activated at 16MHz to feed the TDA8026. A PCA9536 may be used to manage the list of slots (§ 9.3.6.2).
- If a NXP PCA9536 is found the I^2C bus (but no TDA8026), then the presence of a TDA8035 is assumed (§ 9.2). SC_CLK is activated at 4MHz to feed the TDA8035.
- If /SC_IRQ is low and neither a TDA8026 nor a PCA9536 are found on the I^2C bus, then the M519 totally disables its (contact) smart card subsystem.

TBD

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