Data Sheet and Integration Guide

M519-SAM(B)

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PFT25045

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AB

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Revision History

Ver.	Date	Author	Verifier	Approb.	Details
AA	19/02/2025	JDA			Preliminary version
AB	10/04/2025	JDA		TGI	Technical data updated (temperature range, current consumption) Product name changed for M519-SAM(B)

TABLE OF CONTENT

1 Introduction

1.1 Overview

This document describes the functionalities and electrical specifications of the SpringCard SpringSeed M519-SAM(B) running the SpringCore firmware version 1.31 or higher.

The M519-SAM(B) is a OEM NFC/RFID HF module with a remote antenna (balanced) and a SAM smartcard slot.

1.2 Related documents

1.2.1 Documents available as PDF

Reference	Title / Description
PFT22217	M519 Datasheet and Hardware Integration Guide
PMD23175	M519-SRK Getting Started Guide
PNA23174	Using the M519 in PC/SC Coupler mode over a Serial interface
PNA23207	Using the M519 in PC/SC Coupler mode over a USB interface
PNA23208	Using the M519 in Smart Reader or RFID Scanner mode
PNA23189	Using the M519 in SpringProx Legacy mode

1.2.2 Online materials

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

The M519 itself is highly configurable, and supports many operating modes. With its remote antenna, the M519-SAM(B) offers a wide choice or hardware variants. A variety of order codes are available, enabling customers to tailor the M519-SAM(B) to streamline their integration process[A]. However, it must be remembered that changing the configuration of the device in the field or on the production line is straightforward, ensuring flexibility in deployment scenarios.

Order code	Description	Mode	MOQ
SC25114	M519-SAM(B) with 69x45 balanced antenna and 15cm cord[B]	PC/SC	1 unit
SC25118	M519-SAM(B) main board only (no antenna, no cord) [B]	PC/SC	10 units
SC25119	69x45 balanced antenna for M519-based devices (no cord)	—	10 units
SC25120	25x25 balanced antenna for M519-based devices (no cord)	—	10 units
SC25121	80x80 balanced antenna for M519-based devices (no cord)	—	10 units
SC25122	15cm cord for balanced antenna	—	10 units

Note A

Any custom configuration may be created upon request, with a MOQ of 120 units. Contact SpringCard Sales team for more information.

Note B

The M519-SAM(B) is provided without any USB nor Serial cords. See § 2.6 for the accessories.

Warning

The in-the-field reconfigurability of the M519-USS allows for post-deployment modifications of the configuration. Consequently, a device's actual setup is likely to differ from its delivery setup. This may be a source of confusion for after-sales services, when doing a retrofit or when ordering new batches.

It is therefore recommended that customers (customers, integrators, etc.) carefully document any modifications made to the original configuration, keep a record of updates, and share this information with their own quality control, production and technical support teams.

When ordering new batches, it is also advisable to specify the desired configuration, to ensure consistency with the devices already deployed.

2 About the SpringSeed M519-SAM(B)

2.1 General description

The SpringCard SpringSeed M519-SAM(B) is a compact OEM NFC/RFID HF versatile device that integrates the SpringSeed M519 core module and a ID-000 slot for a contact smartcard (SAM) on a single board, to be associated with a remote 13.56MHz antenna board.

The SAM slot uses a smooth push/pull drawer mechanism. Its location on the short side of the main board makes it easy to manipulate the smartcard without having to dismantle the assemblies.

The antenna of the M519-SAM(B) is balanced (symmetrical), enabling it to deliver the best radio performance in a limited space, while ensuring good immunity to noise and easing the respect of EMC constraints. The basic 69x45mm antenna is the same size as the main board, making it easy to assemble into a finished product, but other antenna sizes can be chosen.

The M519-SAM(B) 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 basic 69x45mm antenna is optimised for ID-1 cards (class I, II and III as per ISO/IEC 14443-1) and smartphones, while maintaining compatibility with smaller form factors tags. A larger antenna (such as 80x80mm) will provide a larger operating volume, at the cost of a larger footprint and the risk of not seeing the smaller classes (IV, V and VI as per ISO/IEC 14443-1) in all positions. A smaller antenna (such as 25x25mm) reduces the size of the product and behaves better with small classes, at the cost of a shorter communication distance.

The M519-SAM(B) inherits all the operating modes from the SpringSeed M519 core module (PC/SC Coupler, Smart Reader, RFID Scanner, etc), with a choice between USB and Serial interfaces. At electrical level, the Serial interface is RS-232.

The M519-SAM(B) is designed to be used in industrial equipment, professional terminals or consumer devices.

The overall dimensions (69x45mm), the location of the mounting holes and the connectivity (Serial on JST-8, USB on JST-5) make it a drop-in replacement for earlier SpringCard products such as TwistyWriter and CrazyWriter.

2.2 Features and benefits

2.2.1 Ease of integration into any machine or assembly

- Small design (69.0x45.0mm, 6.2mm max. thickness),
- NXP PN5190 NFC/RFID HF frontend allowing best in-class performance/power ratio,
- NXP TDA8035 ISO 7816 smartcard interface, ID-000 SAM slot,

- Self-antenna tuning capability to deliver optimal performance even in harsh environments,
- Single-source power supply, power saving modes, low power card detection on less than 10mA.

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 device even from low-end MCUs,
- Single hardware supporting both a USB interface and a RS-232 Serial interface,
- 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 (list of our repositories: https://github.com/springcard),
- 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,
- Digital layer of the Contactless stack tested[1] against the following test suites :
  - EMV CL L1,
  - NFC Forum CR13,
  - CEN/TS 16794 aka ISO/IEC TS 24192, RCTIF,
- 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.
- Support of ST25 families, and more.

2.3 Typical applications

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

2.4 Integration and development

This document is the starting point for the M519-SAM(B) integration process. Additional useful information can be found in the SpringCard document base.

[1] Tests carried out in-house do not prejudge the compatibility. As the M519-USS is an OEM module, it is in any case the integrator's responsibility to verify the compliance and obtain Analog and Digital approvals for the end product.

2.4.1 Hardware

The integration of a loop antenna generating an alternating magnetic field and communicating in the near field with passive targets requires control of the electromagnetic environment.

Document [PMI9C2P] provides the recommendations that must be followed.

2.4.2 Software

The M519-SRK is a complete Starter Kit for customers who want to evaluate the SpringSeed M519 core module and then build their own solution around it. It makes it easy for integration and development engineers to get to grips with the module.

Software developers who want to integrate the M519-SAM(B) in their solution will find all relevant information in the Getting Started Guide that comes with the M519-SRK ([PMD23175]) and with the related Application Notes.

2.5 Pictures

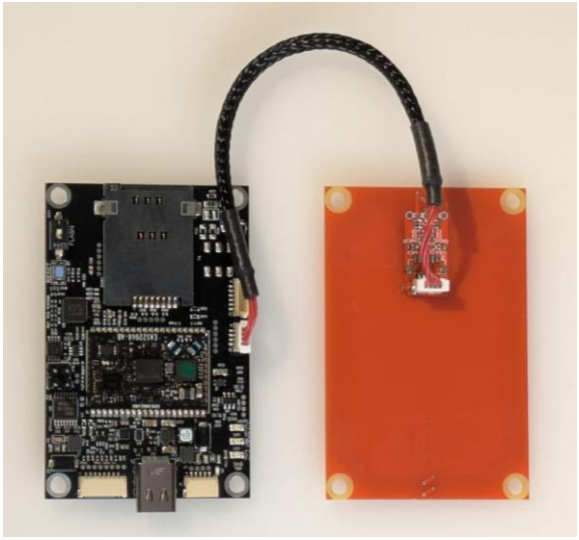


Figure 1: M519-SAM(B), top view (with 69x45mm antenna)

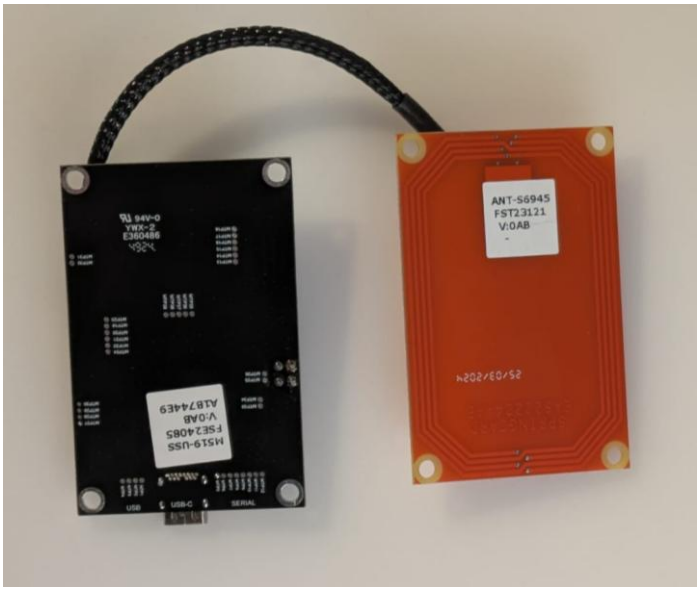


Figure 2: M519-SAM(B), bottom view (with 69x45mm antenna) (actual label depends on part number)

2.6 Related accessories

2.6.1 Serial interface and cord

Order code	Description	Remark	MOQ
SC24051	USB to Serial JST-8 interface, RS-232/RS-TTL/RS-485 level selectable by switches	SC15145 cord included USB Mini-B cord not included Based on FTDI USB to Serial bridge, driver available on www.ftdichip.com	1 units
SC15145	JST-8 to JST-8 cord, 30cm (red wires)		15 units
SC15046	JST-8 to free wires, 30cm (red wires)		15 units

Warning 1

On delivery, the default electrical level of the SC24051 interface is RS-TTL. Its switches must be set to position ON, ON (RS-232) before using it with the M519-SAM(B).

Warning 2

The first generations of USB/Serial interfaces (part number SC19227) suffer from a limitation in the current peaks they can supply; therefore, they are not able to power the M519-SAM(B) correctly. Only the “MK2” generation of USB/Serial interfaces (part number SC24051) can be used with the M519-SAM(B).

2.6.2 USB cord

Order code	Description	Remark	MOQ
SC15252	USB-A to JST-5 cord, 180cm (black)		10 units

REMARK

The M519-SAM(B) has two USB connectors: a JST-5 connector (designed for the SC15252 cord) and a standard USB-C connector. Customers wishing to use the USB-C port can purchase standard cords on their own.

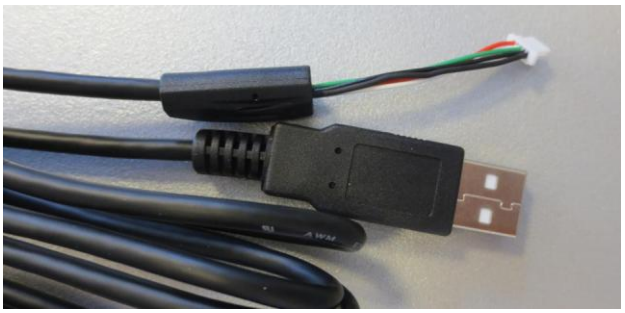


Figure 3: SC15252 USB-A to JST-5 cord

3 Technical data

3.1 General

3.1.1 Main board

Dimensions	69.0 x 45.0 x 6.2 mm
Weight	17gr
Power supply	3.3V or 5V nominal for Serial operation 5V (powered by the bus) for USB operation
Power requirement	Nominal: 200mA Max: 400mA Power saving: < 1mA
Temperature range	Operation: –25°C to +75°C Storage: –40°C to +85°C
Environment	Humidity 0 – 90% (non-condensing)
MTBF	1 230 000 hours
Compliance	CE RED, FCC, REACH, ROHS

3.1.2 Antennas

	69x45	80x80	25x25
Dimensions	69.0 x 45.0 x 6.2 mm	80.0 x 80.0 x 6.2 mm	25.0 x 25.0 x 6.2 mm
Weight	10gr	19gr	3gr
Coil	Balanced, 2x2 loops	Balanced, 2x1 loops	Balanced, 2x8 loops
Gain	–54.4 dBi	–49 dBi	–73.2 dBi
Typical field level	1.5A/m at 50mm	1.5A/m at 52mm	1.5A/m at 25mm
Typical operating distance[A]	Up to 80mm	Up to 85mm	Up to 45mm
Temperature range	Operating: –40 to +85°C Storage: –40 to +85°C		
Environment	Humidity 0 – 90% (non-condensing)		
MTBF	79 000 000 hours		
Compliance	REACH, ROHS		

Note A

The actual operating distance depends mainly on the characteristics of the target (card, tag or NFC object) and the constraints of the electromagnetic environment (noise, detuning, eddy currents, etc).

3.2 NFC/RFID HF (contactless) interface

Carrier frequency	13.56MHz
RF power	Max 2W (33dBm)
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)[B]	NFC Forum types 1, 2, 3, 4 and 5 MIFARE Classic with CRYPTO1 All cards in NXP MIFARE families: MIFARE Plus, MIFARE UltraLight, MIFARE DESFire, All cards in NXP NTAG and ICODE families Innovatron (Calypso cards) STMicroElectronics SR & LR, ST25 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

Note B

MIFARE®, MIFARE Classic®, MIFARE Plus®, MIFARE UltraLight® and MIFARE DESFire® are registered trademarks of NXP B.V. . All other trademarks belong to their respective owners.

3.3 Smartcard (contact) interface

Form factor	ISO/IEC 7810 ID-000 “mini-SIM” (2FF)
Card power classes	5V (class A, max 65mA) 3V (class B, max 65mA) 1.8V (class C, max 35mA)
Card clock frequency	4MHz
Supported standards	ISO/IEC 7816-2, 7816-3 T=0 and T=1, 7816-4
Bitrates	TA1=11 (10752bps) to TA1=18 (129032bps) or TA1=96 (250000bps)
Endurance	5000 insertions

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

Standard	EIA-232 (RX/TX @–12/+12V)
Bitrate	38400bps (default), up to 500kbps after handshaking
Format	8 data bits, 1 stop bit, no parity, no flow control
Protocols	CCID over Serial SpringProx Legacy SpringCore Direct RDR MK1 $SCRDR

4 Mechanical specifications and pinouts (main board)

4.1 Dimensions

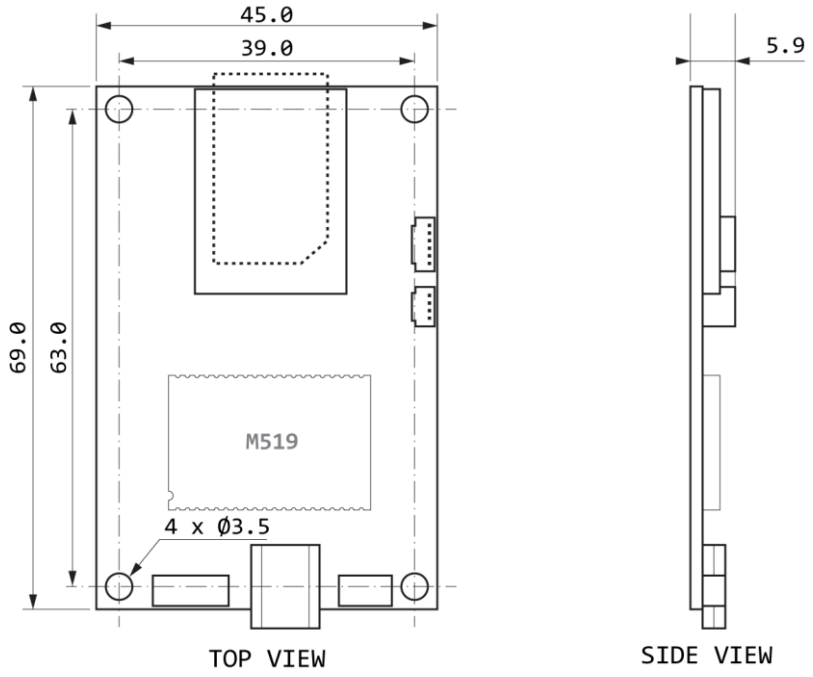


Figure 4: Mechanical specifications, M519-SAM(B) main board

4.2 Pinout

4.2.1 USB-C connector (J1)

J1 is a USB type C connector, dedicated to connecting the M519-SAM(B) with its host, using USB as primary interface.

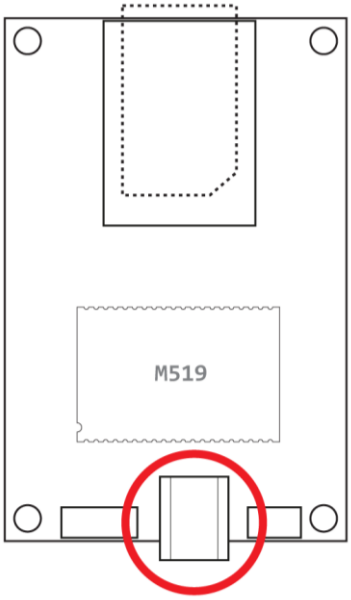


Figure 5: J1 location

Warning

Do not connect J1 and J5 at the same time!

4.2.2 JST-5 USB connector (J5)

J5 is a JST SM05B-SRSS-TB(LF)(SN) 5-position connector, dedicated to connecting the M519-SAM(B) with its host, using USB as primary interface.

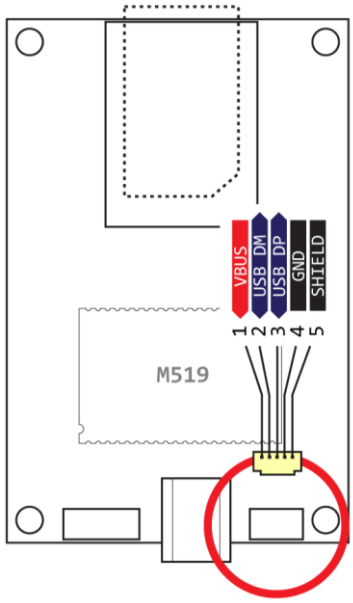


Figure 6: J5 location and pinout

Pin	Symbol	Type	Description
#1	VBUS	Power	Power supply + USB presence, 5V
#2	USB_DM	USB	USB D- signal
#3	USB_DP	USB	USB D+ signal
#4	GND	Ground	Ground signal inside the USB cord
#5	SHIELD	Ground	Shield of the USB cord

Warning

Do not connect J1 and J5 at the same time!

4.2.3 JST-8 Serial connector (J2)

J2 is a JST SM08B-SRSS-TB(LF)(SN) 8-position connector, dedicated to connecting the M519-SAM(B) with its host, using Serial (RS-232) as primary interface. Power is supplied to the device through the VCC (3.3V or 5V) power input.

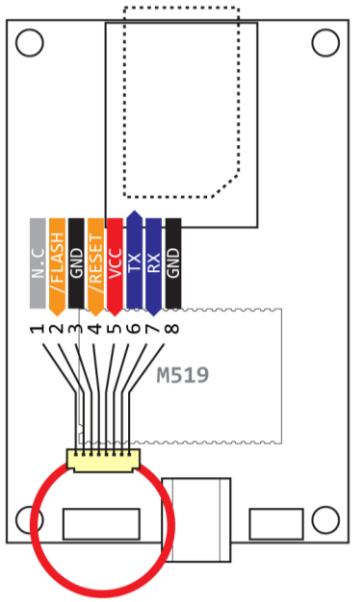


Figure 7: J2 location and pinout

Pin	Symbol	Type	Description
#1	NC	—	Leave unconnected
#2	/FLASH	In	M519's force bootloader signal
#3	GND	Ground	
#4	/RESET	In	M519's reset signal
#5	VCC	Power	External power supply, 5V or 3.3V
#6	TX	Out	UART, RS-232, M519 to host
#7	RX	In	UART, RS-232, host to M519
#8	GND	Ground	

4.2.4 JST-4 Antenna connector (J3)

J3 is a JST BM04B-SRSS-TB(LF)(SN) 4-position connector, dedicated to connecting the M519-SAM(B) main board with its antenna.

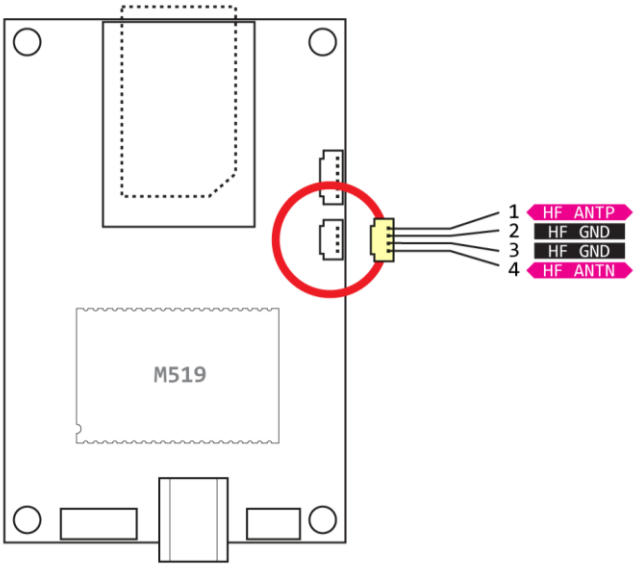


Figure 8: J3 location and pinout

Pin	Symbol	Type	Description
#1	ANT	Analog	Antenna coil (+)
#2		Ground	
#3		Ground	
#4	NANT	Analog	Antenna coil (-)

Warning

Do not connect J3 and J4 at the same time!

4.2.5 JST-6 Antenna connector (J4)

J4 is a JST BM06B-SRSS-TB(LF)(SN) 6-position connector, dedicated to connecting the M519-SAM(B) main board with its antenna.

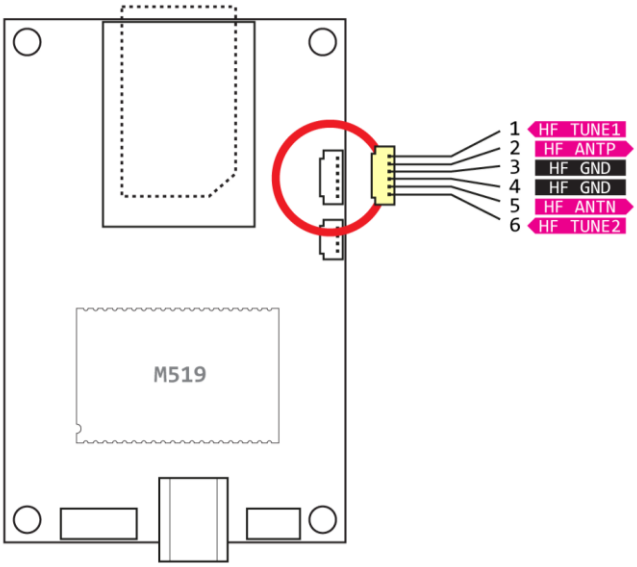


Figure 9: J4 location and pinout

Pin	Symbol	Type	Description
#1	VTUNE1	Analog	Antenna tuning C_S varicaps (serial)
#2	ANT	Analog	Antenna coil (+)
#3		Ground	
#4		Ground	
#5	NANT	Analog	Antenna coil (-)
#6	VTUNE2	Analog	Antenna tuning C_P varicaps (parallel)

Warning

Do not connect J3 and J4 at the same time!

4.3 LEDs

The M519-SAM(B) features 4 LEDs:

- LED 0 is on the M519 module itself; see [PFT22217] for details.
- LED 1: module is powered by VCC (Serial interface).
- LED 2: module is powered by VBUS (USB interface).
- LED 3: RF power is OK.

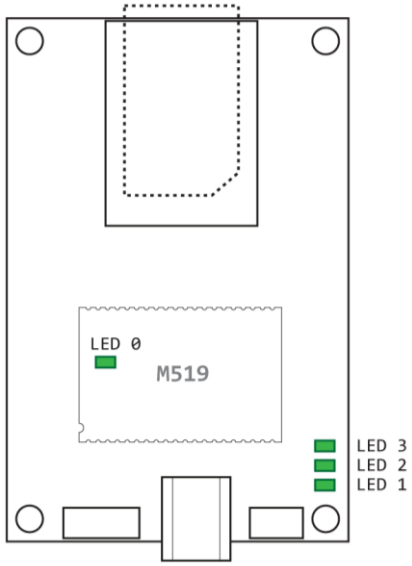


Figure 10: Location of the LEDs

5 Electrical specifications (main board)

5.1 Limiting values

Symbol	Parameter	Conditions	Min	Max	Unit
VCC_{ABS}	Supply voltage on pin VCC		0	5.5	V
$VBUS_{ABS}$	Supply voltage on pin VBUS		0	5.5	V
V_{DIG}	Voltage on any digital pin	Powered by VCC	0	VCC + 0.2	V
		Powered by VBUS	0	VBUS + 0.2	
V_{ESD}	Electrostatic discharge voltage		–500	500	V
$T_{JUNCTION}$	Junction temperature		—	+120	°C
$T_{STORAGE}$	Storage temperature	No voltage applied	–40	+85	°C

Warning

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.

5.2 Power

5.2.1 Power supply voltage

5.2.1.1 USB operation

Symbol	Parameter	Min	Typical	Max	Unit
VBUS	Power supply, USB	4.5	5.0	5.2	V

Warning

The Serial interface (J2) shall be left unconnected for USB operation.

5.2.1.2 Serial operation

Symbol	Parameter	Min	Typical	Max	Unit
VCC	Power supply, Serial	3.0	3.3 or 5.0	5.2	V

Warning

The USB interface (J1 and J5) shall be left unconnected for Serial operation.

5.2.2 Current consumption

REMARK

Max RF power may be restricted by configuration, to reduce the total power requirement, at the price of a shorter operating range.

5.2.2.1 USB operation

Symbol	Parameter	Min	Typical	Max	Unit
$I_{VBUS,IDLE}$	VBUS active but device not enumerated	—	50	60	mA
$I_{VBUS,RF\ OFF}$	Device enumerated, RF not active	—	50	60	mA
$I_{VBUS,RF\ ON}$	Device enumerated, RF active	—	200	340	mA

5.2.2.2 Serial operation, VCC=3.3V

Symbol	Parameter	Min	Typical	Max	Unit
$I_{VCC,RF\ OFF}$	RF not active	—	80	90	mA
$I_{VCC,RF\ ON}$	RF active	—	450	630	mA
$I_{VCC,LPCD}$	Waiting for a card, low power mode	—	7.5	—	mA

5.2.2.3 Serial operation, VCC=5V

Symbol	Parameter	Min	Typical	Max	Unit
$I_{VCC,RF\ OFF}$	RF not active	—	40	50	mA
$I_{VCC,RF\ ON}$	RF active	—	200	340	mA
$I_{VCC,LPCD}$	Waiting for a card, low power mode	—	7.5	—	mA

5.3 Serial interface

5.3.1 RX pin

Symbol	Parameter	Min	Typical	Max	Unit
V_{IL}	Low level input voltage	—	–5	0.6	V
V_{IH}	High level input voltage	2.4	5	—	V
R_I	Input resistance	3	5	7	kΩ

5.3.2 TX pin

Symbol	Parameter	Min	Typical	Max	Unit
V_{OL}	Low level output voltage (at I_{OL}=1mA)	—	–5.4	–5	V
V_{OH}	High level output voltage (at I_{OH}=1mA)	5	5.4	—	V
I_{OS}	Short circuit output current	—	±35	±60	mA
SR	Up or down transition time	—	—	0.4	µs
R_O	Output resistance	300	10M	—	Ω

5.4 /RESET and /FLASH pins

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

5.5 Smartcard interface

5.5.1 Card VCC signal

Symbol	Parameter	Min	Typical	Max	Unit
V_{SC_VCC}	Nominal card supply voltage - class A - class B - class C	 4.75 2.85 1.71	 5.00 3.00 1.80	 5.25 3.15 1.89	V
$V_{SC\_VCC,TR}$	Transient card supply voltage - class A, current spike of 40nA/s - class B, current spike of 40nA/s - class C, current spike of 15nA/s	 4.65 2.76 1.66		 5.25 3.24 1.94	V
$V_{SC\_VCC,RIP}$	Peak-to-peak ripple voltage			0.3	V
I_{SC_VCC}	Card supply current - class A and class B - class C			 65 35	mA
SR	Slew rate - class A - class B - class C	 0.055 0.040 0.025	 0.18 0.18 0.18	 0.8 0.8 0.8	V/µs
t_{desact}	Emergency deactivation time	35	90	250	µs
$I_{SC\_VCC,OM}$	Output current limit - class A and class C - class B	 90 90	 125 160	 160 260	mA

5.5.2 Card CLK signal

Symbol	Parameter	Min	Typical	Max	Unit
$V_{SC\_CLK,OL}$	Low-level output voltage	0		0.15 V_{SC_VCC}	V
$V_{SC\_CLK,OH}$	High-level output voltage	0.9 V_{SC_VCC}		V_{SC_VCC}	V
$t_{SC\_CLK,R}$	Rise time			16	ns
$t_{SC\_CLK,F}$	Fall time			16	ns
DC	Duty cycle	45		55	%
SR	Slew rate - class A - class B - class C	 0.2 0.12 0.072			V/µs
$I_{SC\_CLK,OM}$	Output current limit	-70		+70	mA

5.5.3 Card RST signal

Symbol	Parameter	Min	Typical	Max	Unit
$V_{SC\_RST,OL}$	Low-level output voltage - class A - class B and class C	 0 0		 0.3 0.2	V
$V_{SC\_RST,OH}$	High-level output voltage	0.9 V_{SC_VCC}		V_{SC_VCC}	V
$t_{SC\_RST,R}$	Rise time			200	ns
$t_{SC\_RST,F}$	Fall time			200	ns
$I_{SC\_RST,OM}$	Output current limit	-20		+20	mA

5.5.4 Card IO signal

Symbol	Parameter	Min	Typical	Max	Unit
$V_{SC\_IO,OL}$	Low-level output voltage	0		0.15 V_{SC_VCC}	V
$V_{SC\_IO,OH}$	High-level output voltage	0.9 V_{SC_VCC}		V_{SC_VCC} + 0.1	V
$V_{SC\_IO,IL}$	Low-level input voltage	-0.3		0.2 V_{SC_VCC}	V
$V_{SC\_IO,IH}$	High-level input voltage	0.6 V_{SC_VCC}		V_{SC_VCC} + 0.3	V
$I_{SC\_IO,IL}$	Low-level input leakage current			600	µA
$I_{SC\_IO,IH}$	High-level input leakage current			10	µA
$V_{SC\_IO,HYS}$	Hysteresis voltage	0.03	0.07	0.12	V
$t_{SC\_IO,IR}$	Input rise time			1200	ns
$t_{SC\_IO,IF}$	Input fall time			1200	ns
$t_{SC\_IO,OR}$	Output rise time			100	ns
$t_{SC\_IO,OF}$	Output fall time			100	ns
R_{SC_IO}	Pull-up resistance (to SC_VCC)	8k	10k	12k	Ω
$I_{SC\_IO,OM}$	Output current limit	-15		+15	mA

6 Mechanical specifications and pinouts (antennas)

6.1 Dimensions (69x45)

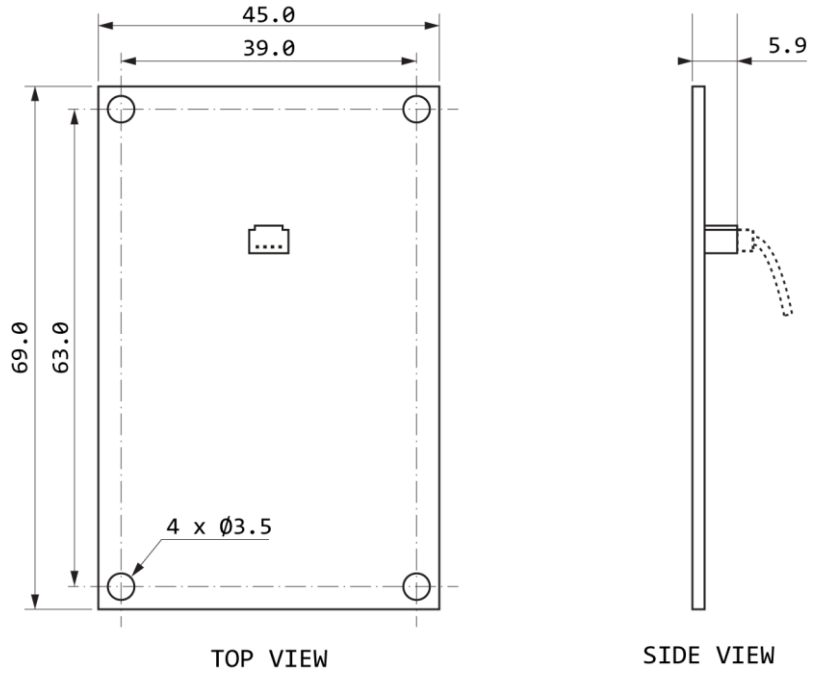


Figure 11: Mechanical specification, 69x45 balanced antenna

6.2 Dimensions (80x80)

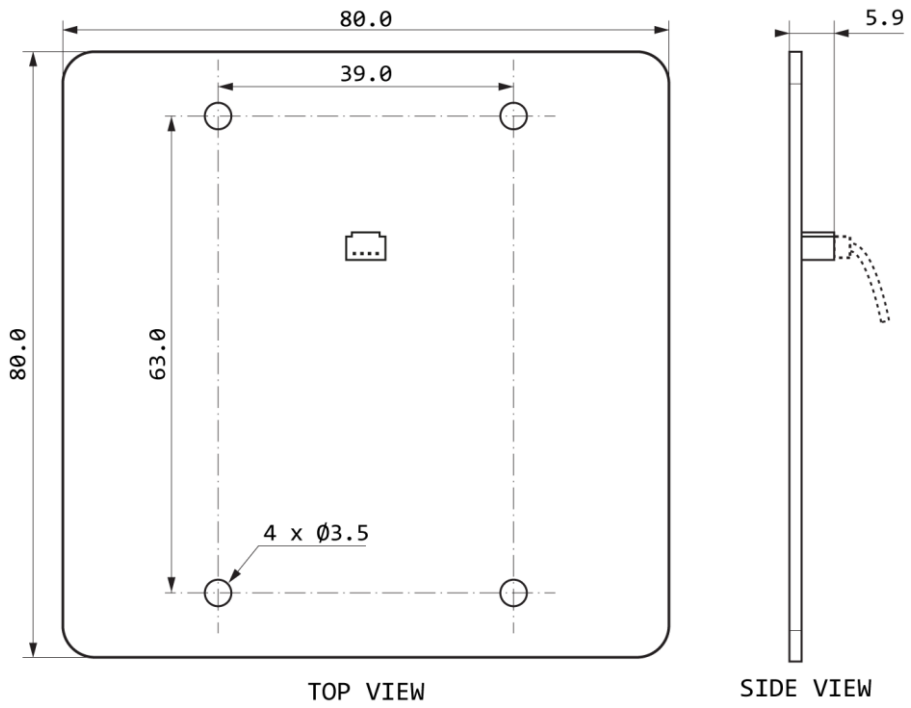


Figure 12: Mechanical specification, 80x80 balanced antenna

6.3 Dimensions (25x25)

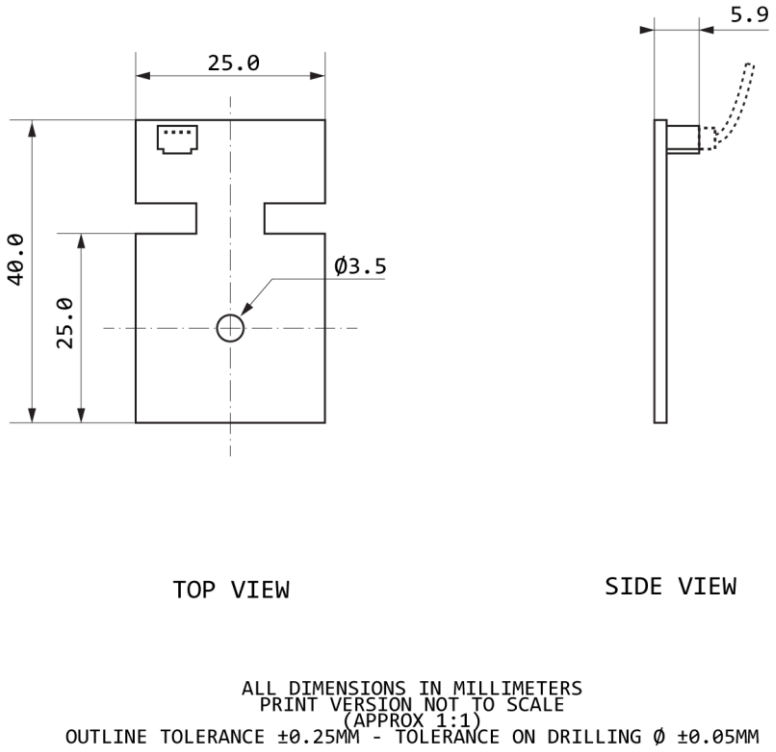


Figure 13: Mechanical specification, 25x25 balanced antenna

6.4 Pinout (common)

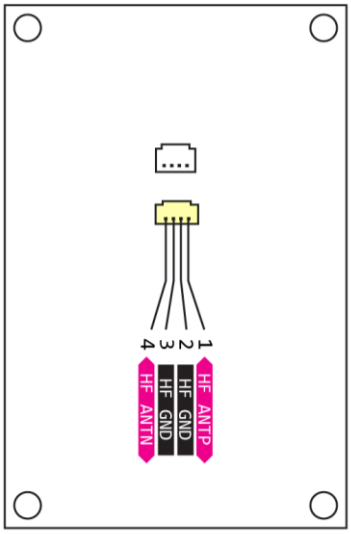


Figure 14: pinout of the balanced antennas

Pin	Symbol	Type	Description
#1	ANT	Analog	Antenna coil (+)
#2		Ground	
#3		Ground	
#4	NANT	Analog	Antenna coil (-)

7 Application information

7.1 Operating modes, profiles and protocols

The M519-SAM(B) is a versatile device, 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 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

7.1.1 PC/SC Coupler mode

In this mode, the M519-SAM(B) 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-SAM(B) is typically associated to a PC/SC driver and is supported by the computer's PC/SC stack. See Application Note [PNA23207] for reference.

The PC/SC Coupler mode is selected by writing $_H$02 into configuration register $_H$02C0.

7.1.1.1 USB

When the PC/SC Coupler mode is selected and the host interface is USB, the M519-SAM(B) is a compound device that exposes both the CCID profile and the SpringCore Direct profile.

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 provided by Apple for macOS.

For Microsoft Windows, SpringCard driver SD16055 shall be used. This driver is available through Windows Update. It could be pre-installed using this setup package:

https://www.springcard.com/en/download/find/file/sd16055

REMARK

Microsoft also provides a CCID driver that works fine with the M519, but unfortunately this driver does not support the SAM slot of the M519-SAM(B), and does not support all the features of the SpringCore firmware. Using SpringCard driver instead simplifies the development and the technical support.

7.1.1.2 Serial

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

See Application Note [PNA23174] for reference.

7.1.2 Smart Reader mode

In this mode, the M519-SAM(B) 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-SAM(B) 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.

7.1.2.1 USB

When the Smart Reader mode is selected and the host interface is USB, the M519-SAM(B) is a compound device that exposes both the HID keyboard profile and the SpringCore Direct profile.

Thanks to the standard HID keyboard profile, the M519-SAM(B) 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”.

For correct operation, the user must configure the M519-SAM(B) with the same keyboard layout as the host system.

7.1.2.2 Serial

When the Smart Reader mode is selected and the host interface is Serial, the M519-SAM(B) 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
```

7.1.3 SpringProx Legacy

SpringProx Legacy is the proprietary protocol and mode of operation introduced in the 2000's 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-SAM(B) is not a drop-in replacement for earlier devices based on the K531, K632 or K663 generations. The high-level behaviour is the same, but low-level control of the RF interface has to be rewritten. Anyway, in most situations, the migration process is straightforward provided that you have access to the source code of the Legacy application.

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

7.1.3.1 USB

When the SpringProx Legacy is selected and the host interface is USB, the M519-SAM(B) 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-SAM(B) 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.

7.1.3.2 Serial

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

7.2 Firmware upgrade

7.2.1 USB

When the device is connected to the host through its USB interface, upgrading the firmware of the M519-SAM(B) could be done in-the-field, over a live system (live upgrade). The typical firmware upgrade procedure is:

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

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/en/download/find/file/sq20029

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

  https://companion.springcard.com

7.2.2 Serial

Live upgrade is possible over the Serial interface only when the device is configured for the SpringCore Direct protocol, fail-safe mode—which normally never happens in the field.

There are 3 different ways to upgrade a device that is connected through a Serial line,

1. Send the software RESET command to the device, with $_{H}$**FA** $_{H}$**DA** as parameters to have the device restart in bootloader mode, and write the new firmware using the bootloader over the Serial interface,

Documentation of the RESET command:

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

Documentation of the bootloader protocol:

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

2. Assert the /FLASH input line to LOW level and perform a hardware RESET of the device to have it restart in bootloader mode, and write the new firmware using the bootloader over the Serial interface,

Documentation of the bootloader protocol:

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

3. Connect a USB cable temporarily, and perform the firmware upgrade through USB.

Solution 3 is definitively the easiest to implement, but it requires a human intervention over the device.

7.3 Reset configuration

When the M519-SAM(B) is powered-up or its /RESET pin is risen (Low to High transition), the module resets and probes VCC, VBUS and /FLASH to read its reset configuration.

The reset configuration defines:

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

VBUS	VCC	Host interface
5V	—	USB
unconnected	5V	Serial

Do not connect anything to either the J1 or J5 connector unless you want to use USB.

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

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

Leave the /FLASH pin unconnected if your application does not need to activate the bootloader.

7.4 Serial shell

The M519-SAM(B) 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-SAM(B), 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.

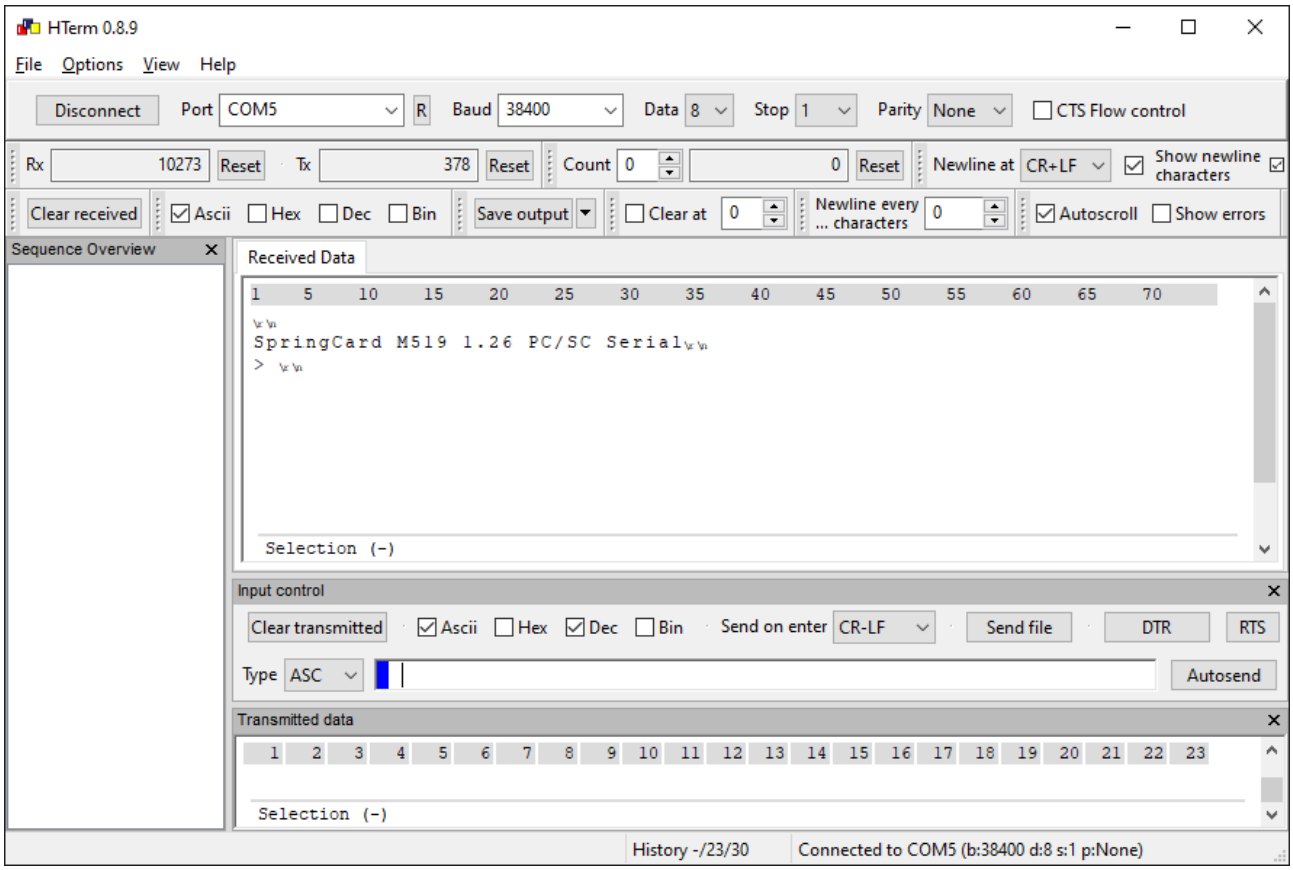


Figure 6: Terminal application 'HTerm' showing the M519's prompt

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.

REMARK

The prompt does not reflect the fact that the device is a M519-SAM(B). The firmware is generic and its prompt is "M519" in all situations.

7.5 Configuring the M519-SAM(B)

The M519-SAM(B) is highly configurable. You may download a configuration file from SpringCard Companion, or use a configuration file provided by SpringCard or a 3rd party. Configuration files use either the JSON or the CFG format.

The new configuration may be injected into the M519-SAM(B) by the mean of a software provided by SpringCard, by the host application itself, or using a secure configuration card *(Master Card)*. When exploring/evaluating the M519-SAM(B), it is also possible to edit the configuration with the shell.

Warning

Writing an invalid configuration may disable the Serial interface and/or the USB interface, and prevent any communication with the device.

7.5.1 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/en/download/find/file/sq20029

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

  https://companion.springcard.com

7.5.2 Configuration through Master Cards

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

7.5.3 Configuration using shell commands

In the Serial shell (see § 37),

- 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).

7.5.4 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-SAM(B).

For reference, please read:

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

7.6 Identifying the configuration of an unknown M519-SAM(B)

The great versatility of the M519-SAM(B) is a key feature that allows a system integrator to use the same device in the widest range of solutions. SpringCard offers a wide range of part numbers so that any manufacturer can order and provision the M519-SAM(B) in the exact configuration required by their product line, but the device can also be easily reconfigured in the field.

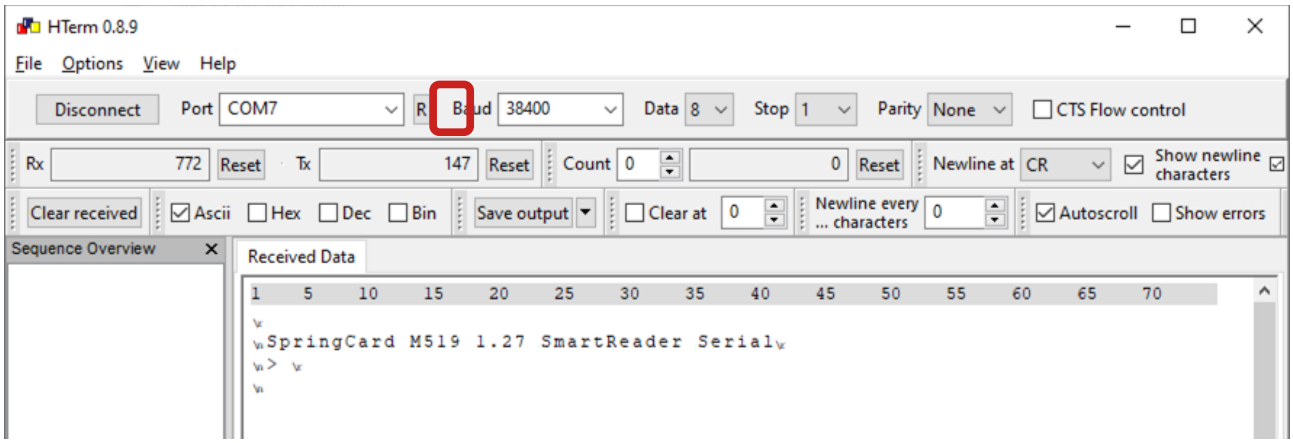
However, this nice feature comes with its side-effect: it makes it difficult for an R&D engineer or a maintainer working on a device that has been deployed in-the-field or used by another developer to guess how the device has been configured, and therefore how it should be connected and operated. Of course the label printed under the M519-SAM(B) tells the out-of-factory configuration, but the current configuration of the device may be different.

In this section we'll learn to identify the main settings.

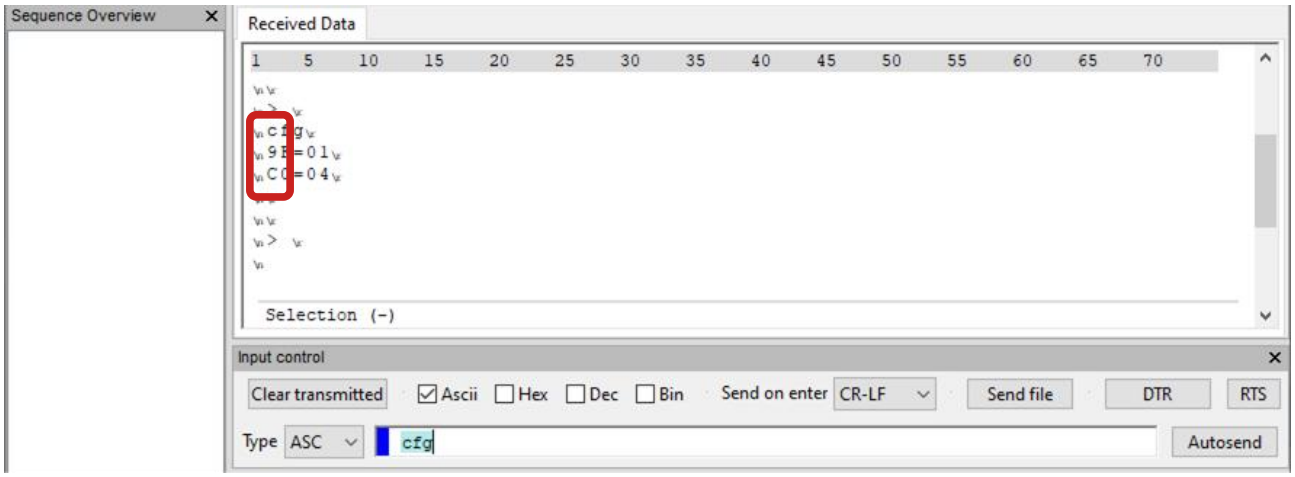
7.6.1 Identifying the operating mode, Serial interface

Connect the M519-SAM(B) to the host using the RS-232 interface. Open a shell onto the device.

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



It is also possible to read-back the configuration by entering the *cfg* command:

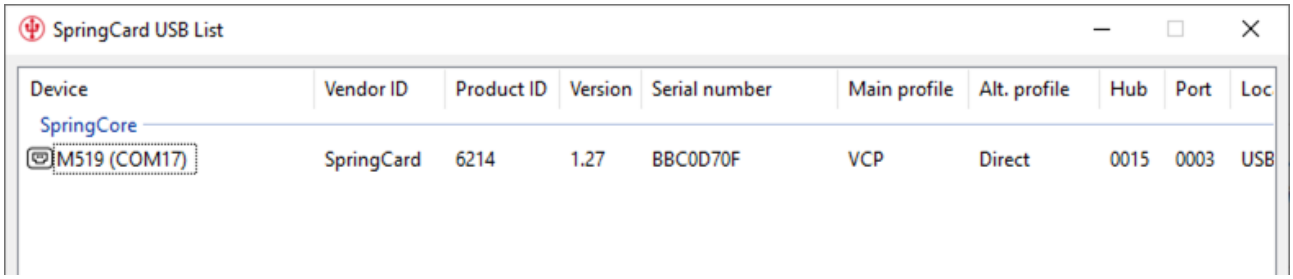


7.6.2 Identifying the operating mode, USB interface

The easiest way of identifying the operating mode of a SpringCard USB device is to download SpringCard UsbList software (for Windows). Look for “USB List” in this download page:

https://www.springcard.com/en/download/find/file/usblist

Launch the software and connect the M519-SAM(B) to the host through its USB interface (see §Erreur ! Signet non défini.). Look for the (newly added *M519* entry in the list of devices, and read its USB Product ID (3rd column).



The mode can be deduced from the Product ID (see §43):

Product ID	Operating mode
H6212	PC/SC Coupler
H6213	RFID Scanner
H6214	Smart Reader
H6211	SpringProx Legacy

8 Integration guide

The M519-SAM(B) supports either USB or Serial as host interface.

The USB interface is enabled by connecting the device to a USB host through the J2 connector.

If VBUS is not active when the module starts, then the Serial interface is enabled.

Warning

For debugging and manufacturing reasons, the Serial interface remains active when the USB interface is enabled, but using both interfaces at the same time is absolutely not supported and is likely to make the M519-SAM(B) reset or behave incorrectly. Leave J2 unconnected when either J1 or J5 is connected.

8.1 USB

8.1.1 Overview

The M519-SAM(B) is a USB 2.0 full-speed (12Mbps) device, compliant with USB 3. Connect the device to the host through J1 (USB-C) or J5 (JST-5) to activate its USB interface.

8.1.2 Precautions

- Use only the JST-5 USB cord provided by SpringCard, or a specific cord explicitly developed and/or validated by SpringCard for your target system,
- Fully extend the USB cord to avoid inductive coupling,
- Place the USB cord perpendicular to the antenna, ensuring that no segment of the cable runs parallel to any side of the antenna,
- Connect the product directly to the computer or exclusively through a USB-certified hub with external power supply; never use a hub that is only powered by the bus; avoid low-quality hubs that have unstable supply voltage or poor noise immunity.

8.1.3 USB IDs, profile and descriptors

The USB profile —and therefore the Product ID and the descriptors announced by the device— depends on the operating mode as selected by configuration register $_H$02C0.

Operating mode	Vendor ID	Product ID	Profile
SpringCore Direct[A]	$_H$1C34	$_H$6210	WinUSB
SpringProx Legacy[B]	$_H$1C34	$_H$6211	Compound, CDC-ACM + WinUSB
PC/SC Coupler[C]	$_H$1C34	$_H$6212	Compound, CCID + WinUSB
RFID Scanner[D]	$_H$1C34	$_H$6213	Compound, HID keyboard + WinUSB
Smart Reader[E]	$_H$1C34	$_H$6214	Compound, CDC-ACM + WinUSB
PC/SC Coupler, no Direct interface[F]	$_H$1C34	$_H$621A	CCID

A: selected by $_H$02C0=$_H$00 and $_H$02C1.bit3=$_B$0
B: selected by $_H$02C0=$_H$01 and $_H$02C1.bit3=$_B$0
C: selected by $_H$02C0=$_H$02 and $_H$02C1.bit3=$_B$0
D: selected by $_H$02C0=$_H$03 and $_H$02C1.bit3=$_B$0
E: selected by $_H$02C0=$_H$04 and $_H$02C1.bit3=$_B$0
F: selected by $_H$02C0=$_H$02 and $_H$02C1.bit3=$_B$1

8.2 Serial

8.2.1 Overview

The serial interface of the M519-SAM(B) is enabled by leaving J1 and J5 unconnected, and by powering the module by the mean of a unique 5V or 3.3V supply over VCC on J2.

The electrical interface is RS-232.

8.2.2 Precautions

- Use short cables and genuine JST male connectors,
- Fully extend the Serial cord to avoid inductive coupling,
- Place the Serial cord perpendicular to the antenna, ensuring that no segment of the cable runs parallel to any side of the antenna.

8.3 Electromagnetic environment

8.3.1 Overview

Communication between the M519-SAM(B) and the contactless target (proximity/vicinity card, RFID label, NFC tag, NFC object…) uses an alternating magnetic field at 13.56MHz and rely on the principle of a transformer (inductive coupling). At the exception of smartphones and battery-powered NFC objects, the M519-SAM(B) also provides remote power to the target.

Such a system is largely impacted by its electromagnetic environment:

- RF waves radiated by surrounding electronics parts, cables or PCB traces alter the signal over noise ratio. This is particularly the case with some displays that radiate their 27.12MHz clock frequency (2x13.56MHz) or with badly shielded USB devices that radiate side-bands around 12MHz.
- RF waves cannot cross conductive materials (PCB ground plane, metallic shield or shell…). More than that, conductive materials in the nearby will host eddy currents (Foucault's currents) so that the RF field will be wasted in heating the material instead of providing power to the contactless objects.

8.3.2 Precautions

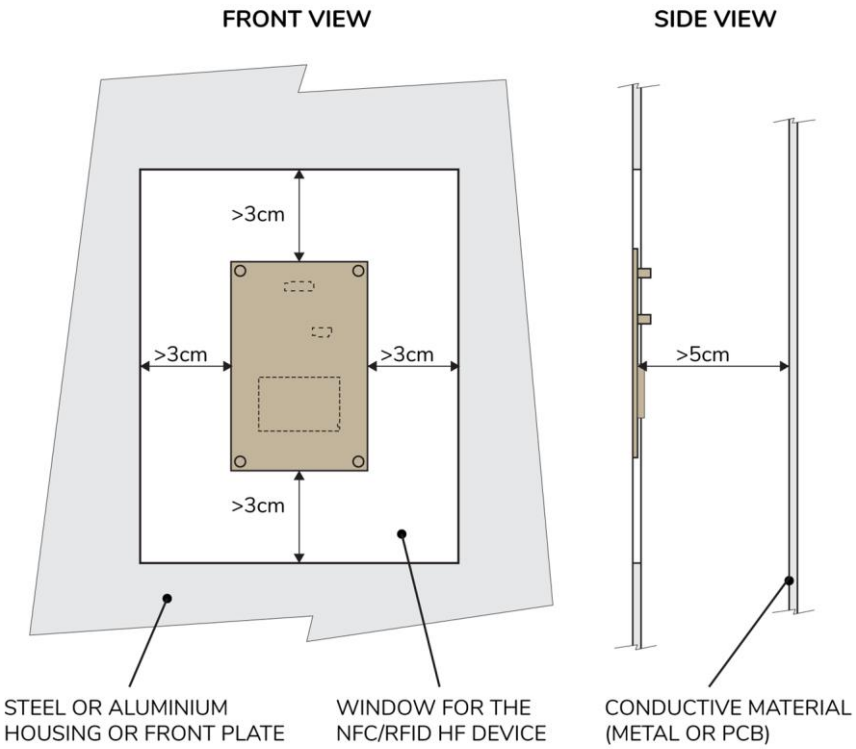
To ensure optimal functionality of the M519-SAM(B), adherence to the following installation guidelines is crucial.

SpringCard has a strong experience in designing NFC/RFID HF devices. Feel free to contact us should you need the assistance of an expert in validating your design.

8.3.2.1 Distance to conductive materials

Avoid any conductive materials in close proximity to the antenna's front. When embedding the M519-SAM(B)' antenna within a metallic body, such as kiosks or gates, create an opening leaving at least 30mm between the antenna and the metal at the sides, and at least 50mm at the back.

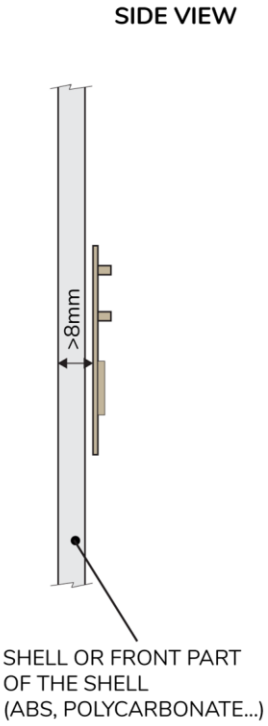
Conductive elements, including PCBs featuring ground planes or parallel traces, as well as cables, must also not be situated near the antenna. Maintain a minimum clearance of 30mm around the periphery of the antenna and ensure a minimum clearance of 50mm at the back of the antenna.



8.3.2.2 Housing

The permeability factor (μ) of materials placed in front of the antenna should be considered. For instance, the permeability of glass or glass-filled plastics have a permeability differing from that of vacuum (μ_0) and air.

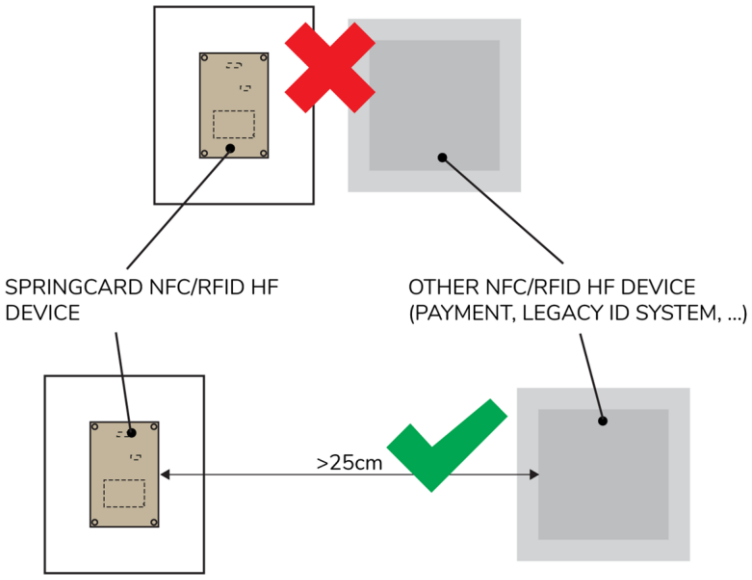
Design the housing or the product shell so a clearance of about 8mm is maintained between the card and the antenna. This enhance the interaction with poorly-tuned cards or with NFC smartphones that expose a significant static load (loading effect) to the base-station.



8.3.2.3 *Electromagnetic environment*

The vicinity should be free of other devices that emit radio frequencies.

A minimum distance of 250mm is advised from any adjacent contactless readers or couplers operating at 13.56MHz. Implement appropriate measures as to mitigate radiated noise within the 12 to 16MHz frequency band.

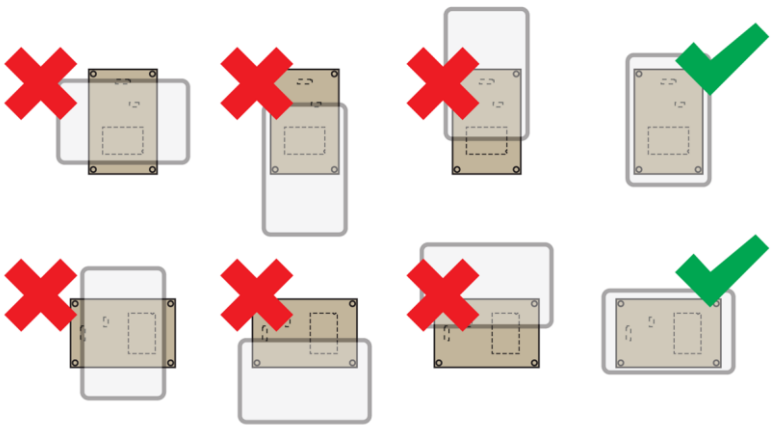


8.3.3 Improving the user experience

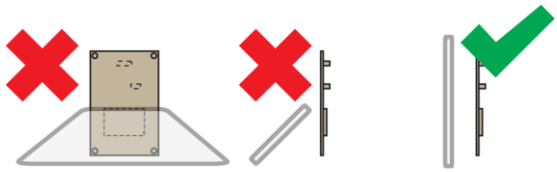
It is advisable to pay particular attention to the design of the system to ensure that the end-user places the card correctly in front of the antenna.

This is even more important when using an antenna that has a preferred direction because it is rectangular (like the default 69x45 antenna of the M519-SAM(B)), rather than square or round.

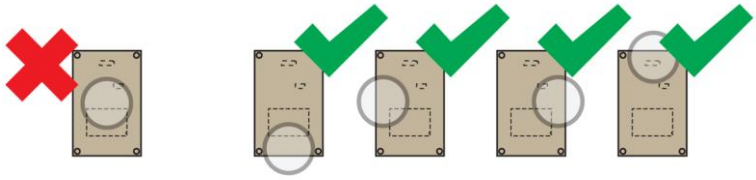
- Optimal performance is achieved when the card is aligned parallel to the antenna, with the longest sides corresponding. Take the user gesture in account when designing the product, and/or position a pictogram over the antenna to indicate the preferred card orientation.



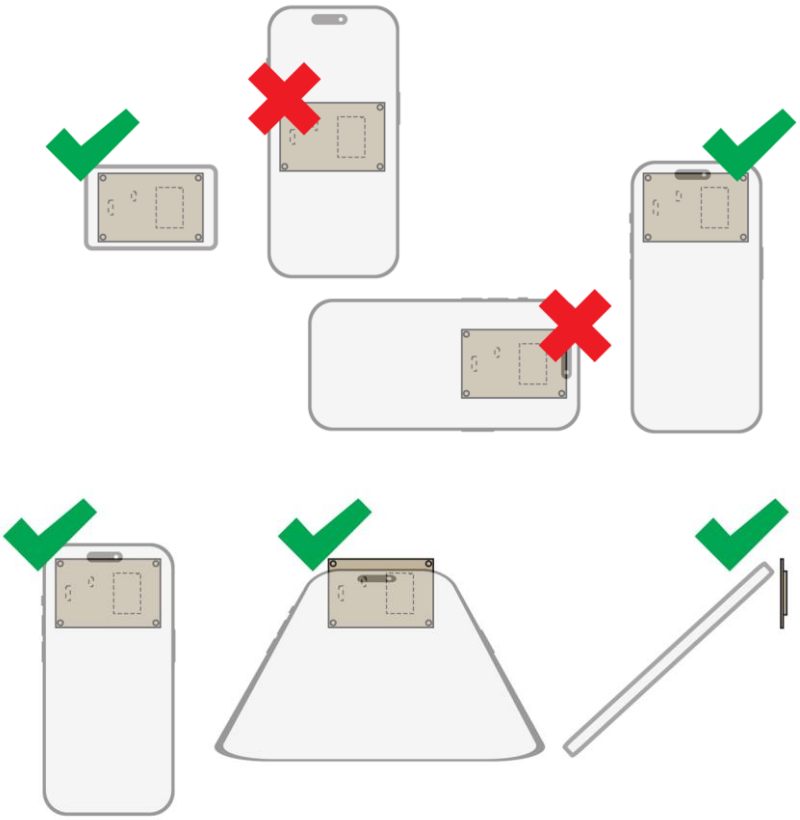
- Ensure the design intuitively guides the user to position the card parallel to the antenna, avoiding any angled placement for consistent communication.



- Smaller NFC tags or RFID labels usually achieve better performance when positioned near the coil's edge as opposed to the antenna's central axis.



- Most NFC smartphones have a preferred axis that is different from that of standard cards, and many are now engineered to communicate more effectively when held at an angle to the antenna.



- Ideally, the end-user shall be made aware of all these particularities via strategically positioned labels, detailed documentation, or targeted educational content to ensure the best possible user experience.

8.4 Testing, validation and qualification

EMC product qualification is imperative for compliance with CE, FCC markings, and other regulatory standards, and must be carried out on the final product. Although the M519-SAM(B) is qualified as an independent device, the performance of the NFC/RFID HF and USB interfaces is contingent upon the integration's quality.

Furthermore, certifications or approvals that are specific to an application field or the targeted use-case (including those from NFC Forum, EMVCo, CEN/TS 16794, ISO/IEC TS 24192, RCTIF etc), must be obtained over the assembled product. This typically encompasses the full software solution and the device's actual configuration in-situ.

SpringCard has a strong experience in designing NFC/RFID HF devices. Feel free to contact us should you need the assistance of an expert in designing or qualifying your own product.

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