OMNIKEY® SE Reader Core

Hardware Developer Guide

PLT-06447, A.0
October 2022

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Contacts

For technical support, please visit: **https://support.hidglobal.com**.

What's new

Date	Description	Revision
October 2022	Initial release.	A.0

A complete list of revisions is available in **Revision history**.

Section 01

Introduction

1.1 Introduction

The OMNIKEY® SE Reader Core is the next generation of embedded reader from HID Global® and is built on a new core platform. The OMNIKEY SE Reader Core replaces both the iCLASS SE® Reader Module family and the BT Xtender Bluetooth Expansion Module, and includes more memory, faster performance, expanded connectivity, and Bluetooth Smart (BLE) while still offering a secure and standards based independent technology and flexible identity data structure based on the Secure Identity Object™ (SIO®). SIO is a portable, open, credential methodology. The OMNIKEY SE Reader Core has been designed for ease of upgrade of existing systems, as it follows the Mk2 iCLASS SE Reader Module format. Mini and Standard sizes are available.

1.2 Scope

This document describes the hardware features of the OMNIKEY SE Reader Core devices and antennas as well as providing guidance for users.

1.3 References

Description	Part
OMNIKEY Secure Element Developer Guide	PLT-06459
iCLASS SE Reader Module MkII Hardware Developer Guide	PLT-02647
DVT Pack 1	3156-701

1.4 Form factors

The OMNIKEY SE Reader Core is available in "standard" and "mini" form factors. The X × Y footprints and solder header connections are backward compatible to the MK2 iCLASS SE Reader Modules[1], but both OMNIKEY SE Reader Cores have a reduced overall height and additional functionality. The OMNIKEY SE Reader Core Standard has expanded connectivity at the wire-to-board connectors and uses 15-way versions of the same Molex Picoblade series connector type.

OMNIKEY SE Reader Core products:

- **RCS**55100000: OMNIKEY SE Reader Core Mini
  The OMNIKEY SE Reader Core Mini has solder header interfaces and a 30-way board-to-board connector.
- **RCL**55100000: OMNIKEY SE Reader Core Standard
  The OMNIKEY SE Reader Core Standard adds three wire-to-board connectors (Molex Picoblade) in addition to the connectivity of the OMNIKEY SE Reader Core Mini.

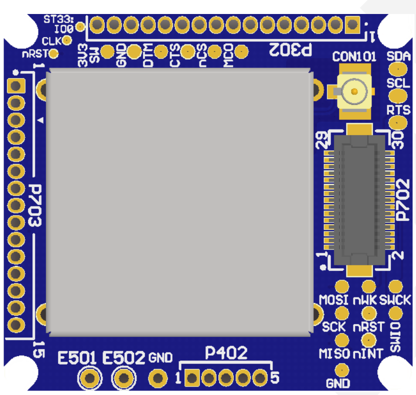
There are a number of enhancements and some differences between the OMNIKEY SE Reader Cores and the iCLASS SE Reader Module; these are summarized in **1.5 OMNIKEY SE Reader Core features and changes**.

Throughout this manual "Reader Core" refers to both the Mini and Standard variants unless noted otherwise. SE32x0B refers to both the SE3200B and the SE3210B Mk2 iCLASS SE Reader Module products.

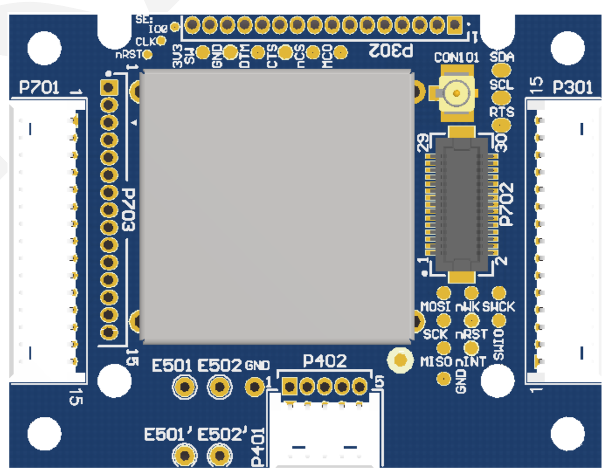
The OMNIKEY SE Reader Core is compatible with existing iCLASS SE Reader Module antennas.

Note that the OMNIKEY OK5127CK Reader Core (part R51270030) is a different product. It is a USB/UART interfaced HF/LF BLE reader with external BLE antenna and HF/LF flexible circuit/coil antenna with built in web interface, complementing the traditional OMNIKEY product line.

OMNIKEY SE Reader Core Mini



OMNIKEY SE Reader Core Standard



1. See **Mechanical specifications** for details. EXP1,2,3 lines no longer supported.

1.4.1 Identifying the OMNIKEY SE Reader Core

By label

OMNIKEY SE Reader Cores have a printed label on top of the metal can. The label includes the part number, such as RCS55100000.

By printed circuit board (PCB) color

- OMNIKEY SE Reader Cores have a blue PCB.
- iCLASS SE Reader Module (SE32X0A) products have a black PCB.
- iCLASS SE Reader Module (SE32X0B) products have a green PCB.

> **Note:** The PCB silk screen does not include the part number. Any revision indication on the PCB is for the PCB only, not the overall product.

1.4.2 OMNIKEY SE Reader Core revision level

Original OMNIKEY SE Reader Cores are at Revision A, marked as "REV:A".

1.5 OMNIKEY SE Reader Core features and changes

A new hardware and software platform is introduced with the OMNIKEY SE Reader Core, with many new features. These are summarized in the following sections.

1.6 Key features

The OMNIKEY SE Reader Core allows integrators to design third-party solutions supporting a full range of contactless card technologies, including HID Prox™, iCLASS®, Seos®, MIFARE DESFire, and NFC applications.

The OMNIKEY SE Reader Core's triple frequency capability allows you to use high frequency (13.56 MHz), low frequency (125 kHz), and BLE frequency credentials with the same reader, providing a solution for mixed credential and credential migration applications. The BLE support enables use of the HID Mobile Access® solution, allowing the developer to support Bluetooth applications that provide user experience and use cases beyond what is available with contactless card technologies.

Another key feature of the OMNIKEY SE Reader Core is the straightforward field upgrade support, which allows firmware changes and feature upgrades for installed readers to extend the lifecycle of customer installations.

Connection to the OMNIKEY SE Reader Core can be made via a 30-way board-to-board connector, wire-to-board Picoblade system connectors, or pin headers to solder holes. Antenna connection is via Picoblade or solder holes for HF, solder holes for LF, and a U.FL connector for BLE.

For quick and easy integration, HID Global provides the OMNIKEY SE Reader Core Developer Tool Kit (DTK). The DTK provides the necessary tools, documentation, and developer resources material to shorten integration cycles and speed time to market with finished products.

- Single platform supporting:
  - Secure Identity Object. Multi-layer security that extends beyond the card technology, providing additional protection for identity data.
  - Triple frequency and NFC capability. Allows straightforward migration by supporting low and high frequency credentials (including iCLASS, HID Prox, Indala® Prox, MIFARE Classic and MIFARE DESFire EV3) and NFC enabled smart phones.
- Field upgradeability gives the installer the flexibility to implement new features in the field and extend product lifecycle.
- A complete flexible product line of reader boards, antennas and accessories.
- Developer tools and support. OMNIKEY provides a fully featured DTK providing software tools and documentation.
- Development support from HID Global EAT RFID Support Services.
- Product pre-certification for industry standard bodies such as modular-FCC and CE/UKCA.
- Ultra Low Power operation for battery-operated devices.
- X × Y footprints are the same as the existing MK2 iCLASS SE Reader Module (both Standard and Mini versions).

1.6.1 New features for the OMNIKEY SE Reader Core

The OMNIKEY SE Reader Core incorporates the following significant new features:

- Bluetooth Smart (BLE) including a U.FL BLE antenna connector for an external antenna.
- USB 2.0 Full Speed interface (in addition to the UART interface).
- New OMNIKEY Secure Element with 2x memory and higher bandwidth (compared with iCLASS SE Processor).
- Dual-core microcontroller.
- On board flash memory IC.
- Low frequency (125 kHz) credential reading at 3.3 V and 3.6 V supply levels (previously required 5.2 V)
- DC/DC switching regulator for better power efficiency.
- 2x tamper inputs.
- UART CTS data flow control signal / interrupt input (alternative configurations).
- UART RTS/DE data flow control/direction enable signal for an external buffer, such as a bidirectional RS485 driver.
- 2x GPIO pins.
- Combined signals on one host interface can eliminate one complete cable compared with Mk2 Reader Module designs.
- Additional serial interface (USART).
- Blue LED support (in addition to green and red).
- External peripheral reset output.
- 3V3-Direct powering option.
- Programable card detection interval.
- OSDP ready.
- Wake from credential detect state upon selected signal changes (revision dependent).
- Total front to back height (Z-dimension) has decreased due to new LF circuitry and thinner PCB (compared with SE32x0B and SE32x0A products).
- Host and serial ports have additional connectivity, while previous connectivity is maintained with the same signals and positions. Ports EXP1, 2, 3 are no longer provided. Various HID only and reserved ports re-purposed for additional functionality.
- 30-way connector has additional connectivity, making use of previously reserved or unused pins.

1.6.2 Changes from the iCLASS SE Reader Module Mk2 (SE32x0Bxx)

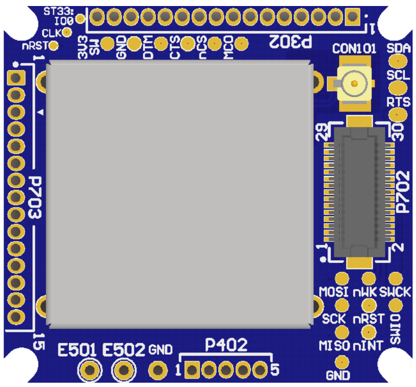
- SAM heater circuit has been removed. A lower temperature range of -25°C (-13°F) now applies.
- Expansion port (passive) connections (EXP1,2,3) removed. These did not connect to any on-board functionality.
- The GND connection on P702 (30-way connector) that was previously used for the BT Xtender module has changed function, as the BT Xtender is no longer needed or supported. This is not the same as the VRTN supply return pins.
- Power supply operating voltage upper limit is now 6 V nominal.
- The Standard version's Picoblade host and serial connectors are now 15-way. Use of a 15-way mating connector part on cables is recommended for best mechanical integrity. Pin 1 onwards is compatible with the corresponding pin on the iCLASS SE Reader Module Large version. The number of wires in the cable does not have to match the width of the port, but each metal crimp will increase the board-to-board attachment integrity. The Picoblade system is profiled so that best mechanical mating is achieved with a connector and receptacle of the same width.
- The 30 mA 3V3 output power supply is no longer supported in the OMNIKEY SE Reader Core (used by BT Xtender previously, but part of the general specification).

> **Note:** The OMNIKEY SE Reader Cores can be used with the existing iCLASS SE Reader Module Mk2 development board (Mk2 version, PCB-00287 Rev A) except for some new functionality and within the 6 V supply limit.

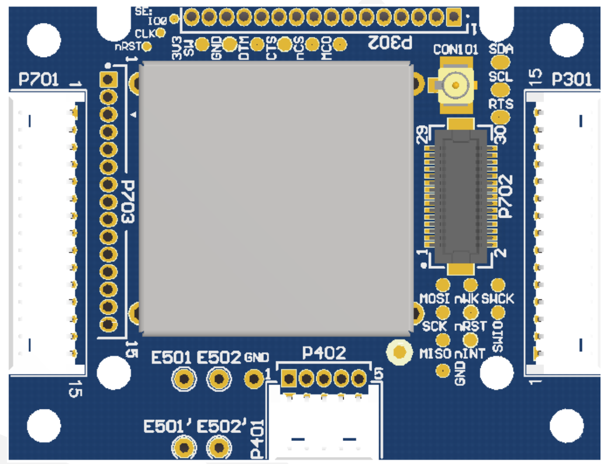
1.7 OMNIKEY SE Reader Core products

The OMNIKEY SE Reader Core is available in two form factors:

OMNIKEY SE Reader Core Mini (RCS55100000)
28 mm × 30.5 mm (1.1" × 1.2")
Matches SE3200B

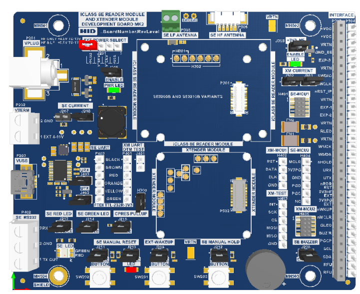


OMNIKEY SE Reader Core Standard (RCL55100000)
33 mm × 43 mm (1.3" × 1.7")
Matches SE3210B



1.7.1 Development tool kit (part 3134BNM0000)

- Development board
- OMNIKEY SE Reader Core Mini
- OMNIKEY SE Reader Core Standard
- HF, HF/LF, and LF antennas and cables
- Bluetooth antenna
- Sample credentials
- Configuration cards
- Quick start guide
- License key for OMNIKEY Developer Portal access



1.7.2 Other tools

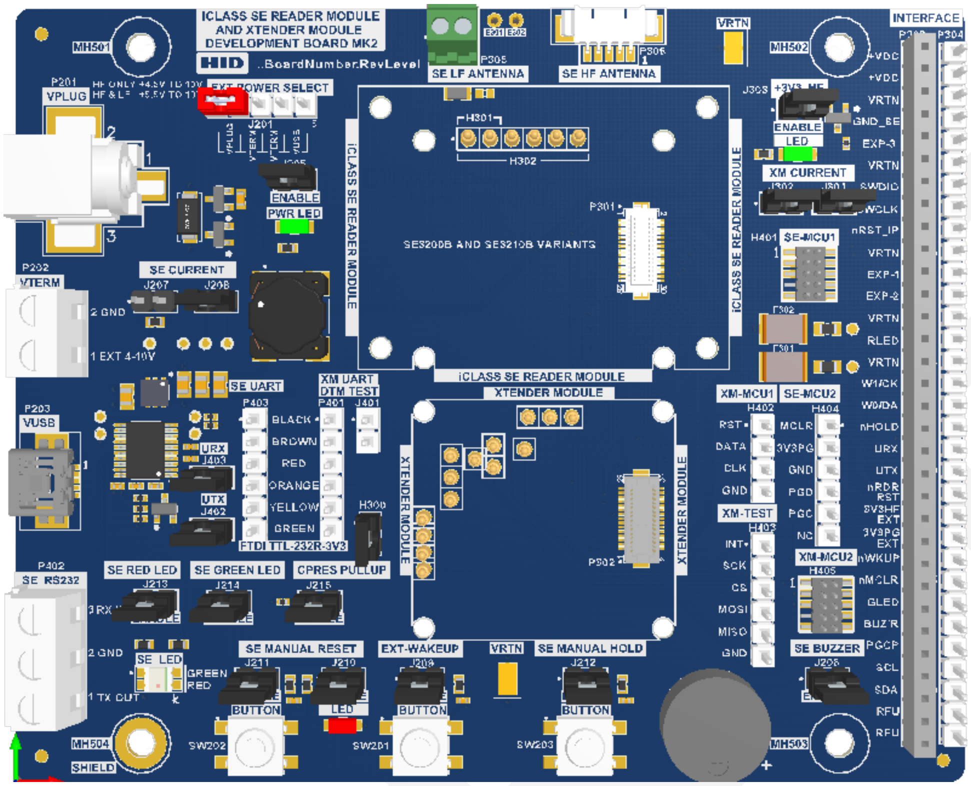
- OMNIKEY Local Reader Manager app (for PCs)
- HID Reader Manager (for mobile devices)

1.7.3 Antennas

- Compatible with existing iCLASS SE Reader Module antennas
- 4090A10 Small Antenna
- 4090A11 Large Antenna
- 4090A16 HF/LF Dual Antenna
- 6500-101-03 125 kHz Prox Antenna
- A51270031 5127CK-Modular Combined Bluetooth Smart Antenna (bulk packed bag of 20)

1.7.4 OMNIKEY SE Reader Core Development Board

A dedicated OMNIKEY SE Reader Core Development Board will be available in the future. The existing iCLASS SE Reader Module Development Board is compatible with the OMNIKEY SE Reader Core, supporting the backward compatible features and also connecting to new 30-way connector features. Observe the 6 V maximum power supply input rating of the OMNIKEY SE Reader Core and do not supply the development board with any higher voltage. This development board is available only as part of the OMNIKEY SE Reader Core Development Toolkit.



1.7.5 RF/UHF variants

The OMNIKEY SE Reader Core can be configured for high frequency card reading only, high and low frequency (Prox), and/or BLE. For full ordering information including options, see the *Embedded Technology Solutions How to Order Guide* (D00551).

1.7.6 Configuration cards

HID configuration cards can be used to change the security configuration or other settings of the OMNIKEY SE Reader Core. Other configuration cards related to HID Mobile Access are also included. Purchased cards include an order number and date for ease of card management.

- Elite Security: Elite enabled devices read only SE Elite credentials with unique matching keys. It works with iCLASS SE, iCLASS SR, standard iCLASS, SE for MIFARE Classic and SE for MIFARE DESFire EV1 with matching Elite keys. Requires an ICE reference number from HID Global.
- Compatibility: OMNIKEY SE Reader Core configuration cards are not compatible with those used with the SE32x0x iCLASS SE Reader Modules (or HID Signo™) and vice versa.

1.8 Terms and abbreviations

Abbreviation/term	Description
ANT	Antenna
ARM	Advanced RISC Machine
ASK	Amplitude Shift Keying (used with some LF credentials)
BLE	Bluetooth Low Energy, or Bluetooth Smart
BOR	Brown Out Reset (self reset when powered below voltage level V<*n*>)
CSN	Card Serial Number
DNC	Do Not Connect
EMC	Electro Magnetic Compatibility
FCC	Federal Communication Commission
FeliCa	Felica Card
FSK	Frequency Shift Keying
HCE	Host Card Emulation
HF	High Frequency (13.56 MHz)
HITAG	A family of 125 kHz credential formats
I/O	Input/Output
IC	Industry Canada (Industry Canada)
LED	Light Emitting Diode
LF	Low Frequency (125 kHz)
MCU	Microcontroller
NFC	Near Field Communications (used by HF readers and some mobile device credentials)
PICC	Proximity™ IC Card
PSK	Phase Shift Keying

Abbreviation/term	Description
R&TTE	Radio and Telecommunications Terminal Equipment
RF	Radio Frequency
RFID	Radio Frequency Identification
SIO	Secure Identity Object
SPI	Serial Peripheral Interface
Ta	Ambient Temperature
TTL	Transistor-Transistor Logic
UART	Universal Asynchronous Receiver Transmitter
UHF	Ultra High Frequency (refers to BLE frequencies in this document)
UID	Unique Identifier
UL	Underwriters Laboratories
ULPM	Ultra Low Power Mode
USART	Universal Synchronous Asynchronous Receiver Transmitter
USB	Universal Serial Bus

Section 02

Overview

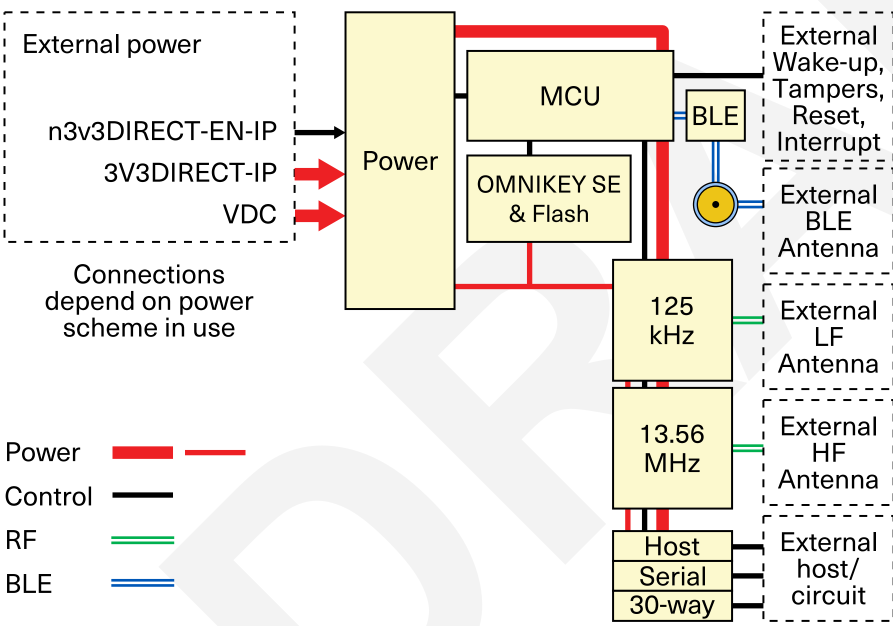
2.1 Features

Type	Feature	Comment
RF interface	ISO/IEC14443	ISO/IEC14443 Type A, MIFARE Classic, MIFARE DESFire 0.6 & EV1
	ISO/IEC15693	CSN only
	Pico15693	ISO/IEC15693 with proprietary protocol
	Pico14443B	ISO/IEC14443 Type B with proprietary protocol
	HID iCLASS	ISO/IEC14443 and ISO/IEC15693 mode
	HID Prox	Where enabled
	Indala Prox	
UHF interface	BT Smart / Bluetooth LE	OMNIKEY SE Reader Core configuration Firmware update (<<TBD>>) HID Mobile Access where licensed
Host interfaces	UART	Host interface
	USART	Host interface
	USB 2.0 FS	Host interface
	Wiegand	Output only binary interface
Expansion interface	I2C	Consult HID
Environmental properties	Operating temperature	-25°C to 65°C (-13°F to 149°F) (Standard, UL Recognized)
	Storage temperature	-45°C to 85°C (-49°F to 185°F)
	Humidity	0 - 90% non-condensing
Certifications	FCC & IC	FCC and Industry Canada Modular Approval
	CE/UKCA marking	R&TTE Directive (Emissions, Indirect ESD, RF Immunity)
	RoHS & REACH	Compliant
	UL Recognized Component	UL 294
	GSA	No

2.2 Architecture and theory of operation

The OMNIKEY SE Reader Core has one dual-core microcontroller (MCU), and this is always powered when the OMNIKEY SE Reader Core is powered. It is responsible for all operations, including low power credential detection, credential reading, and internal power control. The OMNIKEY SE Reader Core has a number of different states, which it moves through in a controlled way according to the operations required. A brown out reset circuit is always active. An HID OMNIKEY Secure Element integrated circuit stores the required digital keys. A discrete flash memory device is used for firmware update. The power to the flash memory and the OMNIKEY Secure Element is controlled by the MCU. HF credential communications use an HF transceiver IC controlled by a serial interface. Serial communication ports allow connection to a host and optionally an expansion circuit. The OMNIKEY SE Reader Core is not designed to supply power to any external circuit. Optional externally powered LEDs and a buzzer can be attached and activated. Power is from an external source and is rectified to 3.3 V by the OMNIKEY SE Reader Core. Credential detection for HF and LF RFID credentials is available using a mixture of discrete circuitry and firmware. BLE support is provided, and a suitable BLE antenna matching circuit is included along with a U.FL connector for an external BLE antenna. An optional 3V3-Direct power scheme is supported, where an external well-regulated 3V3 power supply is used directly by the OMNIKEY SE Reader Core without any further regulation.

OMNIKEY SE Reader Core block diagram



2.3 Power supply

The OMNIKEY SE Reader Core operates from an external power source, which can be a permanent supply or a battery supply. There are two external power scheme options: normal or 3V3-Direct[1]. The normal scheme allows an input supply voltage between 3.6 V and 6 V nominal. The 3V3-Direct scheme operates only at 3.3 V nominal and makes the OMNIKEY SE Reader Core an extension of a host's 3V3 circuits/system, potentially removing the need for a higher voltage supply. This scheme cannot be used at higher voltages (see **Electrical specifications**) and is not intended for use with USB hosts.

Power supply scheme	Supply range (nominal)	Notes
Normal	3.6 V - 6 V	Default scheme
3V3-Direct	3.3V	Requires additional connections as detailed in this section

The OMNIKEY SE Reader Core incorporates flash memory and can be updated. As with any flash-based device, it is important that the host power supply and monitoring system provides and maintains the required supply voltage and current consumption requirements of the OMNIKEY SE Reader Core at all times, to allow it to operate within specifications. This includes when upgrading the OMNIKEY SE Reader Core firmware.

Operating the OMNIKEY SE Reader Core with inadequate power may result in reduced performance or even render the OMNIKEY SE Reader Core inoperative if it enters a brown-out state, for example. If power is determined to be inadequate by the host, then the OMNIKEY SE Reader Core should be placed in reset or power removed from the OMNIKEY SE Reader Core, which could include the host setting hi-Z or low outputs.

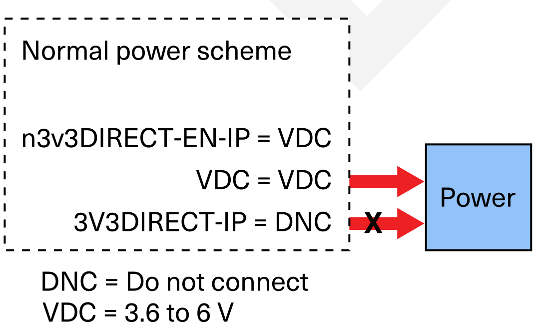
The overall product design must ensure the provision and supervision of a suitable host power supply at all times. The OMNIKEY SE Reader Core includes two levels of voltage detection to help protect it against, and prevent operation with, an inadequate supply. See **Electrical specifications**.

2.3.1 Power architecture

There are two power domains in the OMNIKEY SE Reader Core: 3V3PERM & 3V3SW. Both domains are supplied by the DC/DC switching regulator. The regulator is dynamically controlled between its two states of operation (low and high) by the MCU, as appropriate to the activity of the OMNIKEY SE Reader Core at the time. Power to the 3V3SW domain is controlled by the MCU.

Normal power scheme connections

The external supply is connected to VDC and GND. Pin n3V3DIRECT-EN-IP should be tied to VDC (preferred) or can be left unconnected in a legacy system. Pin n3v3DIRECT-EN-IP has an internal pull-up fitted. Pin 3V3DIRECT-IP must be left unconnected. A 3V3AWAKE-OP pin can be used to indicate that the MCU is awake.



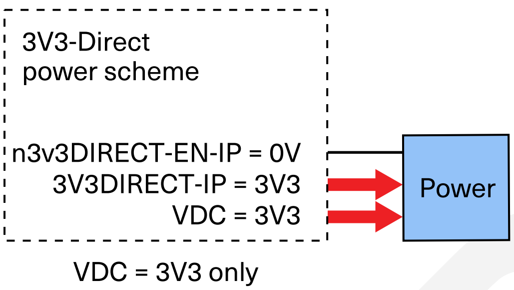
[1] Not supported by Alpha version.

3V3-Direct scheme connections

First, tie any one n3V3DIRECT-EN-IP input pin to GND/0 V to enable this scheme. This is essential and *must* precede connecting the external supply. If the normal scheme is required, leave this pin floating/not-connected or tied to VDC. External power at 3V3 is then connected to VDC and GND pins, and also to the 3V3DIRECT-IP pin(s) for the connection method in use. If using only the 30-way connector, **both** 3V3DIRECT-IP pins must be used.

This supply must be externally regulated and stable to ensure credential detect reliability, and to protect the circuits of the OMNIKEY SE Reader Core. The nature of this scheme, where the OMNIKEY SE Reader Core becomes an extension of the host's 3V3 circuitry, means that the host system must take appropriate measures to protect the OMNIKEY SE Reader Core and also itself, including staying within the specified power supply voltage range. The DC/DC regulator UVLO (Under Voltage Lock-out) function is effectively disabled in the 3V3-Direct scheme. The MCU BOR3 function remains enabled.

Caution: A failure to maintain the n3V3DIRECT-EN-IP pin at 0 V whilst the external 3V3 supply is connected to any 3V3DIRECT-IP pin will result in excessive power consumption and permanent damage to the OMNIKEY SE Reader Core. The n3V3DIRECT-EN-IP pin is not intended to be dynamically controlled. Exceeding the electrical specifications may result in excessive power consumption and permanent damage to the OMNIKEY SE Reader Core. See **Electrical specifications**. The scheme is illustrated below.



2.4 Modes of operation

There are four main modes of operation: Autonomous, CCID, External API and Shutdown. Power saving is integral to the design, so power consumption is reduced whenever possible and allowed.

There is no separate ultra-low power mode (ULPM) because Autonomous mode can reduce power consumption to minimal power levels automatically. The credential detect state consumes power similar to the iCLASS SE Reader Module ULPM mode.

Because the MCU is always powered, certain wake-up events can cause the MCU to leave one mode and enter another and process the cause; this may be a serial communication, external wake-up input, or a tamper or interrupt input, for example.

2.4.1 Autonomous mode

In this mode, different operational states can exist:

Credential detect state

Credential detection operates continuously with minimal power consumption. When a credential is detected, credential polling will start; this state is the default one when using Autonomous mode.

Credential detection can be configured for any/all of HF (13.56 MHz), LF (125 kHz) and BLE credentials. Detecting BLE credentials (by setting a BLE advertising rate and power level) will incur additional power consumption according to the configuration. Three BLE advertising rates are available to choose from: slow, medium and fast. HF and LF credential detection uses dedicated circuitry for each frequency.

This state is designed for fixed location battery powered applications, for example a door or cabinet lock. The OMNIKEY SE Reader Core is constantly monitoring the antenna(s) for an impedance shift in order to detect a card presented to the antenna. Once it has detected an impedance shift on the HF antenna (or the LF antenna, if applicable) it wakes up and polls (and/or advertises) for credentials in the field. If one is detected, the OMNIKEY SE Reader Core reads the data, lowers the Card Present line, outputs the card data, releases the Card Present line, and goes back to the credential detect state within a configured period to conserve power. A fourth wake-up source (External Wake-up) is provided and if asserted will have the same effect.

Awake state

A wake-up event has caused the OMNIKEY SE Reader Core to exit the credential detect state.

Credential polling state

A credential detection or nEXT-WKUP-IP assertion has occurred or the OMNIKEY SE Reader Core is in continuous credential polling state. Credential polling is carried out according to the configured protocols. When a credential is successfully polled (validly acknowledges a poll) then credential reading will start.

Credential polling will use any/all of the HF, LF and BLE transceiver circuits to poll for the configured credential types. Continuous credential polling will be faster to read a credential as the credential detection phase is not used, but will consume more power.

Credential reading state

If a valid response to a credential poll is received, credential reading is performed (according to the configuration, CSN, PACS, DATA) and valid results are reported on the configured communication channel(s). Upon completion of reading and reporting, the OMNIKEY SE Reader Core returns to the configured mode/state.

Hold state

If the nHOLD-IP pin is asserted a hold state will result, with behavior set by the OMNIKEY SE Reader Core configuration settings. When the nHOLD-IP pin is deasserted, the previous mode/state will resume.

CCID Mode

The OMNIKEY SE Reader Core operates with CCID commands received via the USB or serial host interface. Refer to *OMNIKEY SE Reader Core User Guide* (PLT-06682) for details.

USB resume operation is supported, meaning that the OMNIKEY SE Reader Core will enter a credential detection state after a period of inactivity. Exit from the resume state is caused by a wake-up event (including USB activity)<<TBD>> or reset occurring.

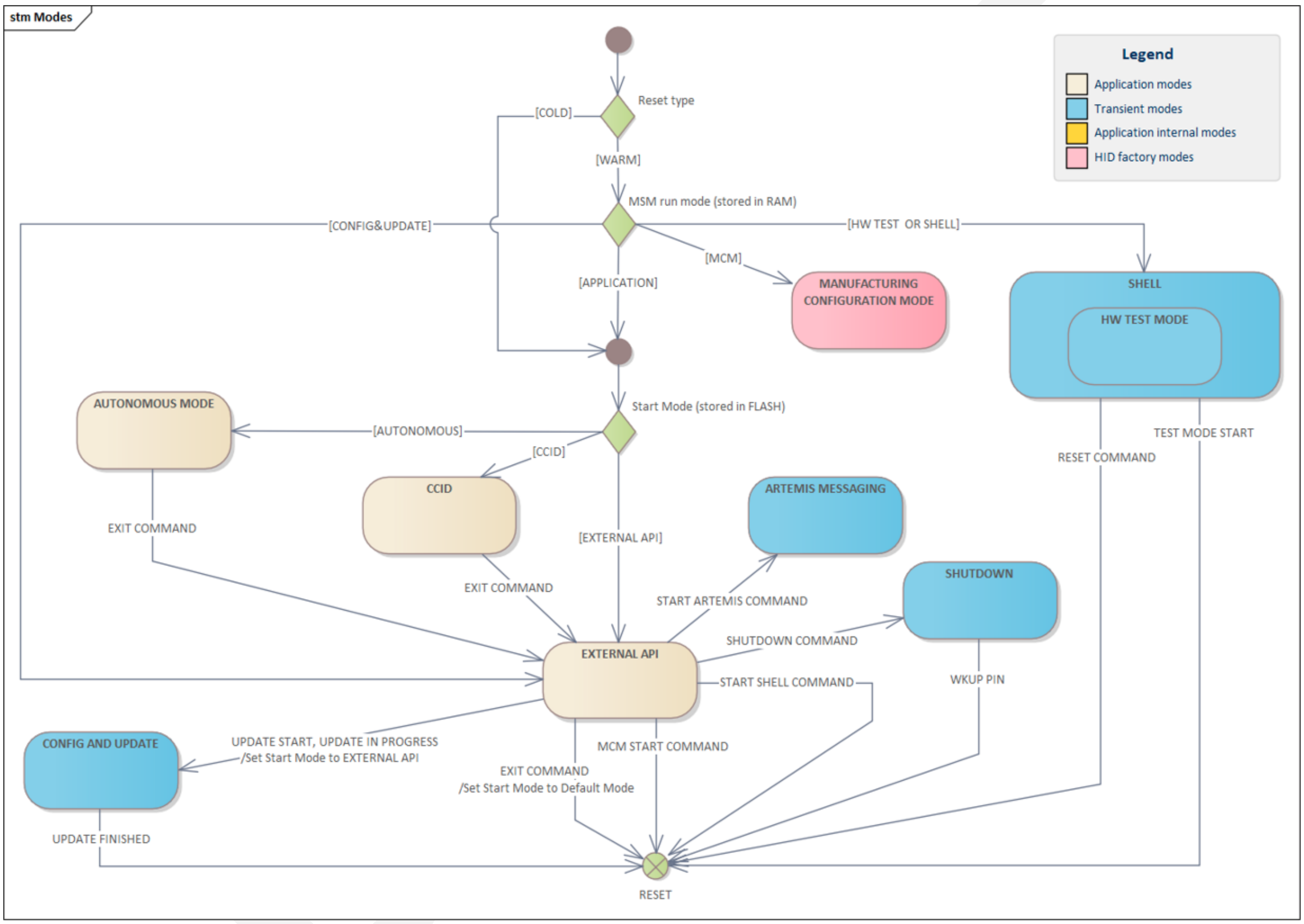
External API mode

This mode allows an external host to communicate with the OMNIKEY SE Reader Core using the API. Commands are encoded in the CBOR format. The host connection can be USB, UART or USART. Refer to *OMNIKEY SE Reader Core User Guide* (PLT-06682) for details.

Shutdown mode (SHUTDOWN)

This mode is designed to minimize power consumption where an external source (logical or physical) can be used to wake up the OMNIKEY SE Reader Core. The OMNIKEY SE Reader Core is placed into its lowest power mode and monitors for a change on any of its wake-up inputs. On receiving a valid change, it enters the configured mode and state (typically credential detection or credential polling state). See **Electrical specifications** for power consumption details.

> **Note:** If developing a hand-held unit, operate the OMNIKEY SE Reader Core in Autonomous mode and, optionally, use SHUTDOWN mode or disable the power when not in use for the greatest power savings.



2.5 Wake-up sources & events

The OMNIKEY SE Reader Core has multiple wake-up sources. A wake-up source is a signal or event that causes the OMNIKEY SE Reader Core to move to the awake state from a lower power state, or to change mode in response. The availability of these sources is dependent upon the mode and state of the OMNIKEY SE Reader Core.

The wake-up sources and effects are shown below:

Ref.	Source	Availability	Response
1	nEXT-WKUP-IP	All modes and states	Moves to credential polling state from credential detect state. Exits SHUTDOWN mode into configured mode and state.
2	nINT-IP	Future capability (not active in SHUTDOWN mode)	Moves to awake state and processes the external interrupt event as configured and per programming. For example, this may indicate an I2C connected peripheral has a service need.
3	UART-RX	Future capability (not active in SHUTDOWN mode)	Moves to awake state and then to External API mode. UART only.
4	nOSDP-TAMPER-IP	All modes and states except SHUTDOWN mode	Moves to awake state and indicates an external tamper event in the configured manner using the configured reporting method.
5	nMCU-TAMPER-IP	All modes and states	Exits SHUTDOWN mode via a reset. When awake, the tamper service routine is entered.
6	nRST-IP	All modes and states	External reset input. This is a level-sensitive input. The OMNIKEY SE Reader Core is held in reset until nRST-IP is deasserted and then resumes the default configured mode and state.
7	HF or LF Ping	Credential detect state	Moves to credential polling state.
8	BT Ping (mobile device response to BLE advert (BLE Ping))	Credential detect and advertising state	Moves to credential polling state.
9	Brown-out reset (BOR)	Shutdown mode: BOR is inactive. All other modes and states: BOR3	MCU resets until BOR condition is removed, then OMNIKEY SE Reader Core resets and resumes configured mode and state.
10	GPIO1,2	Not active in SHUTDOWN state	If configured as an input, the response is configuration and software dependent.

2.6 Connections and peripheral circuits

The following sections detail the function and usage of the OMNIKEY SE Reader Core connections and recommended external circuitry.

2.6.1 Power supply (VDC, GND)

The external power supply connections or supply polarity to the OMNIKEY SE Reader Core must never be reversed, as this will quickly cause permanent damage and prevent the OMNIKEY SE Reader Core from operating. The supply setting must be within the **Electrical specifications**. The OMNIKEY SE Reader Core power supply limits have changed compared with the Mk2 iCLASS SE Reader Module. The maximum has reduced, and an additional alternative option specifically for a 3V3 supply (only) has been introduced; this scheme is called 3V3-Direct. See **2.3 Power supply** and **Electrical specifications**.

2.6.2 External resistors

Floating I/O pins should not be present at the OMNIKEY SE Reader Core when it is included in a product. The OMNIKEY SE Reader Core includes tie-off resistors on selected inputs and outputs.

Additional external pull-down or pull-up resistors may be required depending upon how the host product connects to the OMNIKEY SE Reader Core. See **Connector configuration**, which documents tie-offs already present.

Avoid the accidental provision of a positive voltage to an OMNIKEY SE Reader Core signal (various) or supply-indicator pin (3V3AWAKE) which might provide a phantom powering and consequently reduce battery life or stress components. See also **3V3-Direct scheme connections**.

User-designed circuitry is expected to be (optionally) connected to the red LED, blue LED, green LED/card present and buzzer signals, which are all open-collector outputs.

See also **UART Receive line (UART-RX)**.

2.6.3 Protection from ESD and voltage surges

Only the USB interface has dedicated protection against ESD and voltage surges. Otherwise, as this is an embeddable module, the host circuit must provide protection at any necessary exposed or vulnerable interfaces according to the end product design.

For serial communications, it is recommended that the logic level serial interface(s) are buffered or translated to other transmission standards (such as RS-232 or RS-485) suitable for the distances and environments involved. A direction control signal for an external bidirectional serial driver (such as used for RS-485) is provided by the OMNIKEY SE Reader Core.

2.6.4 External supply noise

A stable VDC voltage is necessary for credential detection. In the normal supply scheme, the VDC voltage is regulated by the OMNIKEY SE Reader Core, but excessive external supply noise or sudden changes in level from the host may cause false card detections to occur. A line filter designed to block frequencies in the 1 kHz to 50 kHz range is beneficial when in-line with VDC. Alternatively, consider increasing the HF and or LF detection threshold value configuration items using the OMNIKEY Reader Management Application. Finally, check that no high noise lines are running close to the OMNIKEY SE Reader Core/antenna/connections. These considerations are also true for the 3V3-Direct power scheme, with the additional constraint that the external 3V3 supply must be regulated within the required tolerances and not subject to noise or step changes as before (see **Electrical specifications**).

2.6.5 Adding external LEDs and buzzer

The LED cathode should be connected through an external current limiting resistor to the appropriate (open collector) connector port.

The value of the resistor depends on how much current is required for the desired LED brightness, and this must be within the specification of the OMNIKEY SE Reader Core output port and also within the combined ports specification. Consider the combined voltage drop of the resistor and the OMNIKEY SE Reader Core output low voltage on these signal lines. It is not possible to vary the LED brightness under software control.

The negative terminal of an external buzzer can be connected (if necessary to meet specifications - through an external resistor) to the Buzzer (open collector) connector port signal. The buzzer signal is a DC signal, not an AC signal, so a tone generating type of buzzer should be used.

2.6.6 Green LED/Card Present, Red LED, Blue LED and Buzzer output waveforms at start-up

These outputs will be inactive at power-on or during a reset.

To determine if the OMNIKEY SE Reader Core is awake, monitor the 3V3AWAKE-OP logical output line, which is active only when the OMNIKEY SE Reader Core is preparing to read a credential, react to a wake-up event, or has otherwise left Shutdown mode or a credential detect state.

3V3AWAKE-OP will activate even if a false credential detect occurs.

A further option is to use the System Start section of the visual template options to make an LED or Buzzer activation indicate that the OMNIKEY SE Reader Core has moved to the normal power state. <<TBD>>

2.6.7 UART (UART-TX, -RX, -RTS/DE, -CTS)

Selected logic level UART signals are available at the connectors of the OMNIKEY SE Reader Core.

The UART-RTS/DE signal can be used to control the direction of an external bidirectional buffer for half-duplex communications (such as an RS485 buffer).

If the serial connection distance exceeds 0.5 m / 1.5 ft or is subject to electrical interference, then the use of external buffers and an appropriately robust electrical connection (such as RS-232 or RS-485 or an optical link) is highly recommended.

UART Receive line (UART-RX)

This input is unbuffered and connects directly to the main MCU. A 100 kΩ pull-up is provided, going via a diode to 3V3PERM. If unused, it can be left unconnected in the host system.

Wake-up on UART-RX

A transition on UART-RX can be used to move the OMNIKEY SE Reader Core from a credential detection or Shutdown mode to the External API state. This means that UART messages to the OMNIKEY SE Reader Core can be initiated even whilst it is not awake. This is a future capability.

UART RX & TX pins (UART-RX, UART-TX, P301, P302 and P702, P701, P703)

The same UART-RX & UART-TX signals are present at multiple ports; only connect to one of each at a time.

2.6.8 USB (USB-P, -N)

A USB 2.0 Full Speed interface is provided on P302 & P702 (30-way interface). P302 pins are arranged so that the four pins of the USB interface are adjacent (connect VUSB to VDC).

The USB has in-built ESD and surge protection (**Electrical specifications**).

2.6.9 USART (USART-RX, -TX, -RTS/DE, -CK/GPIO2)

Selected logic level USART signals are available at the P301 and P302 connectors of the OMNIKEY SE Reader Core.

The USART-RTS/DE signal can be used to control the direction of an external bidirectional buffer for half-duplex communications (such as an RS485 buffer).

If the serial connection distance exceeds 0.5 m / 1.5 ft or is subject to electrical interference, then it is highly recommended to use external buffers and an appropriately robust electrical connection (such as RS-232 or RS-485 or an optical link).

2.6.10 USART and OSDP

The USART interface is targeted as the OMNIKEY SE Reader Core to OSDP panel serial interface, and other OSDP related pins (2 x GPIO, nOSDP-TAMPER-IP, USART-RTS/DE) are also present on the serial port interface at P301 & P302.

USART (USART-CTS/nINT-IP)

The USART CTS input is optionally configurable as an alternative to the nINT-IP input, at P702 only.

2.6.11 Brown-out Reset, UVLO, Reset, insufficient voltage

In-built Brown-out Reset (BOR) and Under Voltage Lock-Out (UVLO) circuitry help protect the OMNIKEY SE Reader Core against the effects of insufficient external supply voltage/power.

If the external supply falls below the input voltage specification for the power scheme in use, a gradual reduction in RFID read range is possible in the region between the minimum Vdc for the power scheme in use and the point at which the Brown-out Reset or UVLO triggers, as Vdc falls.

Brown-out Reset (BOR)

When the OMNIKEY SE Reader Core is supplied with power, a brown-out reset monitor is active in the MCU and will activate it if its supply voltage falls below *Vbor3f*. Deactivation will occur when its supply voltage rises above *Vbor3r*. There is hysteresis between these two levels (see **Electrical specifications**). This applies in all modes and states of operation except during Shutdown mode.

In Shutdown mode, *Vbor0f* and *Vbor0r* apply. However, the UVLO (see below) trigger level is higher than *Vbor0* so will trigger first, followed by *Vbor0f* as residual voltage from decoupling capacitors declines.

During a BOR reset, the OMNIKEY SE Reader Core will be held in a reset state until the supply voltage returns to a sufficient level.

Vbor3f is chosen to best match the working specifications of the components of the OMNIKEY SE Reader Core.

Note that if external power is cut whilst the OMNIKEY SE Reader Core is in Shutdown mode or credential detect state, because of the low power consumption triggering of a brown-out or under voltage condition may not be immediate.

Under-voltage Lock-out (UVLO)

The DC/DC regulator includes an under-voltage lock-out circuit. This activates when VDC is below a pre-set threshold. When active, the regulator is disabled; see **Electrical specifications**. The UVLO threshold is below the *Vbor3f* threshold, so has no effect on the operating voltage range of the OMNIKEY SE Reader Core, but will further decrease power consumption in a situation where the external supply is declining.

Reset (nRST-IP)

Asserting the external reset input nRST-IP (active low), removes power from the 3V3SW domain. The 3V3PERM domain remains powered, including the MCU. Credential detection or credential polling and all communications will be stopped. External wake-ups are not responded to. The OMNIKEY SE Reader Core will consume less power than credential detect mode.

The MCU will be held in reset until the external reset is removed, at which point the MCU will restart code execution.

The effect of nRST-IP, combined with the brown-out reset monitor, remains valid until Vin is incapable of powering the OMNIKEY SE Reader Core effectively, including in a battery powered system. If a valid VDC is restored, nRST-IP will still be effective until it is deasserted.

If an external wake-up activation is present after nRST-IP is deasserted, then this will be processed as normal.

2.6.12 Power supply supervision and assertion of nRST-IP by the host system

The host system must operate the OMNIKEY SE Reader Core within its operating specifications. This means that the host system, especially when battery powered (either permanently or transiently, such as in a back-up battery scenario), should control the power and/or reset input to the OMNIKEY SE Reader Core appropriately. The design of the overall installation (for example, locks and panels) should consider back-up scenarios and operating ranges and the management and maintenance of the equipment providing that functionality.

2.6.13 (Legacy) HID BT-Xtender expansion module

The HID BT-Xtender (Expansion) Module is no longer required for BLE support, since the OMNIKEY SE Reader Core includes it. This provides a major reduction in the volume required for a BLE reader solution, and improved power consumption, especially when BT Ping (advertising) is operating. The OMNIKEY SE Reader Core does not support the BT Xtender Module.

2.6.14 Expansion module capability

An expansion module can be interfaced to the OMNIKEY SE Reader Core using connector P702 (30-way). The module must be independently powered and have compatible logic levels. One USART and one I2C port are available for communication along with interrupt, wake-up, and GPIO pins.

Expansion module guidelines and interfacing

The expansion module capability is designed primarily for one expansion module at a time. Any expansion module will require appropriate firmware to be loaded into the OMNIKEY SE Reader Core to support the module, and therefore collaboration with HID Global. It is not currently possible for customers to write their own firmware for the OMNIKEY SE Reader Core.

Location of the expansion module may be:

- Directly interfaced to the OMNIKEY SE Reader Core using the 30-way expansion connector connected to a mating connector on the expansion module. The two devices are therefore "stacked" with a 5 mm (0.197") separation between them. The expansion module should pass through any signals needed by the main board into which the "stack" has been plugged. This requires a second 30-way connector on the expansion module. Care must be taken to make the arrangement mechanically and thermally stable.
- Directly beside the OMNIKEY SE Reader Core on a separate connector site with direct tracking connections.
- Implemented directly onto a host PCB to which the OMNIKEY SE Reader Core is connected.
- More distantly. It is recommended that no more than 10 cm (3.9") separation is used. Ensure that I2C and other signals still have compliant/satisfactory waveforms for your application if the OMNIKEY SE Reader Cores are separated.

Essential connections between the OMNIKEY SE Reader Core and the expansion module are:

- I2C Clock and Data (SDA, SCL) or USART Serial connections, OMNIKEY SE Reader Core GND connection, nEXT-WKUP-IP & or nINT-IP (nPPH-INT-IP), nPPH-RST-OP
- Other connections such as nRST-IP are optional and depend on the source of the signal within the system architecture.

The expansion module may use a 30-way (Hirose) connector with a greater mated height if required, provide mechanical stability and electrical integrity is addressed.

The 30-way connector (and the mating 30-way part) is not compatible with IDC type (ribbon cable) connections or any flexible wire connection system.

An expansion module should not rely on just the 30-way connector to secure the OMNIKEY SE Reader Core, because it has no specific retention system. They should always include supplementary mechanical fixing methods.

The location of the expansion module compared with the OMNIKEY SE Reader Core can affect power supply and/or signal integrity if the separation is too large, the capacitance is too high, or other high rate or high voltage switched signals (including LF or HF RFID lines) are nearby. Poor signal integrity may impair the reliability of the system.

Use the common GND connection between the host system and the OMNIKEY SE Reader Core GND ports as the power supply return of the expansion module; do not route the GND return solely through the OMNIKEY SE Reader Core.

An I2C protocol interface is supported by the OMNIKEY SE Reader Core (via the 30-way expansion connector, P702) and is intended for use with an expansion module. Pull-ups are included on the OMNIKEY SE Reader Core for both I2C signals at this interface. The I2C SCL clock frequency is 1 MHz. The I2C ports are not buffered and come directly from the on-board microcontroller.

Designers should follow normal good design practice for high-speed serial buses, including specific guidelines for I2C interfaces. The NXP Semiconductors document *I^{2}C-bus specification and user manual* (UM10204) is the definitive source of I2C design information.

An expansion module must be powered from a separate source. Carefully consider the implications on power consumption and phantom powering possibilities.

2.6.15 (Legacy) Mk2 iCLASS SE Reader Module Expansion lines EXP1,2,3

The OMNIKEY SE Reader Core does not include the three passive expansion connections (EXP1,2,3) of the Mk2 iCLASS SE Reader Module. These connections did not connect to any functionality on the Reader Module. The connections have been re-purposed.

2.6.16 HF/LF credential detection system

The OMNIKEY SE Reader Core's credential detection/wake-up system enables it to detect both HF and LF credentials whilst consuming minimal power. The system uses a pulse (credential-detect pulse, also known as a ping pulse) and an algorithm plus configurable thresholds (one for HF and one for LF credentials) to determine the presence or absence of a credential being presented to the external antenna.

The detection threshold of both the HF and LF detection systems can be individually varied or individually disabled in the configuration of the OMNIKEY SE Reader Core. Disabling one of the detection systems will reduce current consumption even further. Disabling both detection systems will make it impossible to reactivate the OMNIKEY SE Reader Core unless an external wake-up source, successful BLE advert (if enabled), an external reset activation, or a power-cycle is used. To effect a change in behavior from this state, externally wake-up, reset, or re-power the OMNIKEY SE Reader Core and provide external API messages or use a BLE or NFC management tool (such as HID Reader Manager) to reconfigure one or both detection systems.

The OMNIKEY SE Reader Core credential detection system has been improved compared with the Mk2 iCLASS SE Reader Module system. A significant addition is the ability to alter the interval between the credential detect pulses. This gives more flexibility to optimize the power consumption for battery powered devices. For example, if card presentations are infrequent, and some delay is acceptable for the user, then the pulse interval can be extended to be longer than the default value. When both enabled, HF and LF detection pulses always occur in pairs, with a fixed minimal interval between them.

Additionally, the duration of the impulse that generates the HF ping (similarly for LF) can be changed to a limited extent. This affects the power consumption very slightly, but also alters the amplitude of the credential-detect pulse. Changes to this value must be within pre-defined limits to maintain correct operation of the pulse evaluation circuit. This ability is intended to help offset the effect of a lossy antenna integration upon credential detection.

These extended features provide a more flexible solution for embedding the OMNIKEY SE Reader Core in different products, and for an enhanced end-user experience, particularly in the case of products with both low and high frequency capabilities.

In use, the credential should be presented towards the reader face in a timely manner - it quickly becomes apparent and natural to do this. An artificially slow presentation, or one that stops too far distant from the reader face, reduces the effectiveness of the detection system. In testing of the product design, testing of the credential detection effectiveness requires a test that can present the credential in a timely manner.

It is also possible to individually adjust the LF and HF detection thresholds that need to be reached when presenting a credential in order to trigger the jump into the higher power credential reading mode. These settings affect the user experience. See the following section for more details.

If the product is an HF-only product, disabling the LF ping system will reduce the power consumption.

Credential detection system thresholds and enables

The credential detection systems (LF and HF) both work on a threshold principle, where a minimum threshold count needs to be reached before the system triggers the rest of the OMNIKEY SE Reader Core to be powered up and to read the detected credential. The higher the threshold, the closer the credential has to be to the antenna to be detected.

> **Note:** The detection distance also depends on the mutual coupling between the credential and the antenna, which itself depends on the attached antenna shape, size, and position and the credential's antenna shape and size.

The latest OMNIKEY SE Reader Core management application supports these new features. It allows the user to set a threshold for the LF detection circuit and another for the HF detection circuit, to enable or disable either the LF and or the HF detection circuit, and to read the values of the thresholds. These thresholds are crucial to reliable operation of a product using credential detection. If the threshold is set too low false triggers may occur, and if set too high some or all credentials may not trigger the exit from credential detection. The threshold entries are not bounded because this provides the greatest product usage flexibility, for example power saving by using only the appropriate detection mechanism. However, as each product enclosure and environment is different, the user will need to experiment with threshold values. A default threshold value for both LF and HF systems is set by HID Global.

OMNIKEY SE Reader Core HF and LF Thresholds

It may be the case that a threshold in the region of 5 or less may experience false triggers. For the OMNIKEY SE Reader Core, 0x7 is at the lower extreme of the workable threshold range and requires a stable external power supply not prone to sudden changes or interference. This is especially true for the 3V3-Direct scheme where the external supply connects to an unregulated version of the 3V3PERM power domain. For more margin against accidental wake-ups, consider a higher HF threshold (e.g. 0xD or more) and/or a higher LF threshold (e.g. 0x1D or more). The LF credential detect is more sensitive to noise due to the longer period it is operational. Because of the algorithm and circuit differences, a higher threshold in the OMNIKEY SE Reader Core is not directly proportional to detection distance when compared with the Mk2 iCLASS SE Reader Core.

Thresholds can be easily changed using the management tool.

> **Note:** Disabling a detection type does not alter the frequency of occurrence of the other detection type.

HID Mobile Access credential detection (BLE Advertising / BLE Ping)

The OMNIKEY SE Reader Core includes a dedicated MCU (one of the two in the dual-core MCU) for HID Mobile Access support. There are two ways of detecting an HID Mobile Access credential, BLE Ping and TAP:

BLE Ping

The OMNIKEY SE Reader Core continually advertises itself and the mobile device establishes a connection when in range. This is the BLE equivalent of the credential detect pulse. Using BLE Ping will increase the power consumption of the OMNIKEY SE Reader Core to the credential detect and advertising state level. The configurable advertising rate can be set to slow, medium or fast, and power consumption will increase as the rate increases. The frequency of advertising is within a range to optimize collision avoidance with other sources.

Rate choice	Power consumption	Default frequency of advertising	Detection
Slow	Lowest	Between every 1000 ms and 1200 ms	On average the credential will be closest to the OMNIKEY SE Reader Core when detected.
Medium		Between every 100 ms and 150 ms	
Fast	Highest	Between every 30 ms and 60 ms	On average the credential will be furthest to the OMNIKEY SE Reader Core when detected

BLE Ping is suitable for longer range HID Mobile Access credential detection, in an environment with well spaced readers or readers without line of sight between units, or a single reader such as a front entrance door. It is essential to figure the advertising transmission power and the RSSI threshold appropriate per installed device to avoid inappropriate connections.

BLE Ping with the OMNIKEY SE Reader Core is materially more efficient than the BT Xtender / MK2 iCLASS SE Reader Module combination, having fewer processors involved and because of the highly integrated nature of the dual-core MCU.

TAP

TAP uses the OMNIKEY SE Reader Core HF Ping to detect the HID Mobile Access device. The OMNIKEY SE Reader Core must be configured to use BLE as one of the credential polling protocols (as well as or instead of HF, LF protocols such as 14443A, B, etc.). Upon detection of the mobile device, BLE advertising will commence and HID Mobile Access verification will proceed. TAP uses the credential detection state power consumption.

VDC ripple and credential detection

Different host systems use different methods to generate the supply voltage to the OMNIKEY SE Reader Core (VDC). Some systems may result in better or worse load regulation than others. Sometimes the supply voltage to the OMNIKEY SE Reader Core is shared with, or affected by, other active/intermittent loads which may cause dips and/or ripple on VDC. Although the OMNIKEY SE Reader Core has on-board regulation circuitry, it cannot be completely immune to all external VDC fluctuations. In credential detect state, fluctuations particularly in the 100 Hz to 5 kHz region of sufficient amplitude may cause a false wake-up of the OMNIKEY SE Reader Core. If they coincide with the credential detect process the result of the process can be affected. The longer duration LF detection is more susceptible than the HF detection. Increasing the detection threshold(s) can be effective in combating ripple. Equally, if excessive VDC fluctuations are unavoidable but predictable, the host system may be able to take this into account when operating/interacting with the in OMNIKEY SE Reader Core.

Early credential detection

> **Note:** Some credentials may be detected before they can be read. In such a case, consider increasing the detection threshold, but ensure that HID configuration cards can still be read if they are expected to be used. If you have greater control flexibility, consider issuing a "re-try" to read the credential.

Threshold enabling and threshold levels in general

> **Important: If the LF, the HF, and the HID Mobile Access (BLE Ping) detection mechanisms are disabled in the applied configuration, and there is no other source of wake-up (e.g. an external wake-up source/communication from an external device, a power reset, or a wired reset) then the OMNIKEY SE Reader Core will be unable to wake up and it will be effectively disabled.**

Previous experience suggests that a HF threshold above 30 (decimal) is unlikely to be needed, and too high a threshold may result in failure to detect some/many HF credentials. All figures are dependent on enclosure and antenna arrangement. The detection thresholds are stored in NVM, so are retained when the system is unpowered.

Credentials with multi-stage power consumption

Some credentials may go through two or more stages of power consumption, such as a lower power request and anti-collision stage followed by a higher power encrypted data transaction exchange (as compared with a lower power unencrypted exchange), for example MIFARE Plus S with custom data. In normal operation where the credential is moved towards the reader face in a timely manner, such staged power consumption may not be an issue. With a credential detection system, detection of such credentials may be able to be adjusted (by pinger threshold change or ping impulse width change) to be inside the point where the system is capable of supplying the maximum power requirement of the credential; this is most practical in systems where the intended credential type is known. Ensure that HID configuration cards can still be read and processed correctly. If you have greater control flexibility, consider issuing a "re-try" to read the credential.

Credentials with high self-resonant frequency

Credentials with higher than normal self-resonant frequency will decrease the detection and the read ranges available unless they also consume less power through technology advances. This is a natural consequence of the credential design and applies to any 13.56 MHz system.

2.6.17 External Wake-up Input (nEXT-WKUP-IP)

The External Wake-up input (active low) has a 100 kΩ pull-up resistor on the OMNIKEY SE Reader Core and is designed to be connected to an open-drain or open-collector drive on an external device or devices attached via the 30-way connector (pin 17, P702:nEXT-WKUP-IP). This allows the potential to have more than one external wake-up.

When nEXT-WKUP-IP is taken low by the external source, the wake-up system will be triggered (if not already active) and will move the OMNIKEY SE Reader Core to the awake state. Credential polling will be initiated.

The external wake-up must be deasserted before returning the OMNIKEY SE Reader Core to the credential detect state. If the external wake-up signal is not deactivated, then an endless loop of wake-up, shut-down, wake-up, shut-down may result.

An external wake-up transition will be processed asynchronously to the credential detect operations and will not be delayed by the credential detect sequence.

> **Note:** If you intend to develop an interacting custom external module, such as a touch keypad for example, contact the HID EAT Technical support team to discuss the development, bearing in mind that custom firmware may need to be developed.

2.6.18 External Tamper Input (nOSDP-TAMPER-IP)

The External Tamper input (active low) has a 100 kΩ pull-up resistor on the OMNIKEY SE Reader Core. External Tamper is a logical input with behavior controlled by the MCU firmware. Support for nOSDP-TAMPER-IP is a future capability and not present in the current OMNIKEY SE Reader Core.

In general, a typical OSDP response to a tamper event would include:

- Generate an internal OSDP tamper status.
- Report it in a Local Status Report (osdp_LSTATR) sent in response to an osdp_LSTAT command or as a "poll response".

2.6.19 External MCU Tamper Input (nMCU-TAMPER-IP)

The External MCU Tamper input (active low) has a 100 kΩ pull-up resistor on the OMNIKEY SE Reader Core. nMCU-TAMPER-IP is configurable as an MCU dedicated tamper input with appropriate internal hardware support capabilities. Assertion of MCU Tamper will wake up the OMNIKEY SE Reader Core from Shutdown mode. Tamper event recording/processing/clearing is configuration and mode dependent. Refer to *OMNIKEY SE Reader Core User Guide* (PLT-06682).

2.6.20 External Interrupt Input (nUART-CTS/nINT-IP)

The External Interrupt input (active low) is an alternative functions pin, shared with nUART-CTS. The function is chosen by configuration. It has a 100 kΩ pull-up resistor on the OMNIKEY SE Reader Core and is 5 V tolerant. On assertion, the MCU will execute an interrupt handling routine and identify that an external interrupt has been asserted. The subsequent actions will depend upon the firmware loaded into the OMNIKEY SE Reader Core. It is designed to be connected to an external device that requires to alert the OMNIKEY SE Reader Core to an event (such as a keypad signaling that a key has been pressed and that keypad interaction is required across the expansion port (I2C)). If the OMNIKEY SE Reader Core is in the credential detect state, nINT-IP as a wake-up source can be available. If Shutdown mode is active, the OMNIKEY SE Reader Core will/will not exit Shutdown mode.

2.6.21 UART Receive (UART-RX)

This is a 5 V compatible input with pull-up. The pull-up is via a diode to protect reverse feeding power into the OMNIKEY SE Reader Core. The input is not buffered.

2.6.22 UART Transmit (UART-TX)

The UART Transmit output is not buffered and is driven directly from the MCU.

2.6.23 UART nCTS (nUART-CTS/nINT-IP)

The UART nCTS pin is an alternative functions pin, shared with nINT-IP. The function is chosen by configuration. Use of nCTS requires UART hardware flow control to be enabled, and is used in conjunction with the remote host.

2.6.24 External Hold Input (nHOLD-IP)

The active-low nHOLD-IP input can be used to suspend operation of the OMNIKEY SE Reader Core by placing it in a hold state. It has an internal pull-up and can be left floating/unconnected if required. The external driving source can be open-collector, open drain, or driven high or low. nHOLD-IP is a direct way to suspend operation of one or many OMNIKEY SE Reader Cores at the same time.

The hold state power consumption is detailed in **Electrical specifications**.

The operation of the OMNIKEY SE Reader Core in the hold state has two configurable options:

Parking mode

When nHOLD-IP is asserted, the reader's RF transceiver circuits and credential detect circuits will turn off, until the line is released. This input can be connected to the contact or logic output of a vehicle loop detector, so that the reader will not accept a card unless a vehicle is detected. If nHOLD-IP is asserted during a credential read, the read will stop without completing and the hold state will be entered.

Wiegand mode

When nHOLD-IP is asserted, the reader will buffer one card read (ignoring subsequent reads) until the line is released.

2.6.25 External Peripheral Reset Output (nPPH-RST-OP)

nPPH-RST-OP is an active-low open-collector output which can be used by the OMNIKEY SE Reader Core to reset a connected expansion module(s) or circuit(s). It is asserted when the OMNIKEY SE Reader Core is reset or determines that the expansion module or circuit is unresponsive. This is dependent upon the loaded OMNIKEY SE Reader Core firmware.

2.6.26 External LED/Card Present Outputs (nRLED-OP, nBLED-OP, nGLED-CPRES-OP)

The external LED outputs are active-low open-collector circuits which are activated by the OMNIKEY SE Reader Core according to its configurations. The outputs are conventionally labeled to indicate Green, Red and Blue LED usage. The nGLED/nCPRES-OP output has a dual function: Green LED enable and Card-Present indicator. When asserted low, it indicates that credential data will be placed onto the selected serial port (or Wiegand outputs).

The LED behavior, and the trigger for the behavior, is controlled by the configuration of the OMNIKEY SE Reader Core. Multiple behavior patterns can be configured to provide different LED indications for different events. Refer to *OMNIKEY SE Reader Core User Guide* (PLT–06682) for details, including defaults.

2.6.27 External Buzzer Output (nBUZZER-OP)

The external buzzer output is an active-low open-collector driver which is activated by the OMNIKEY SE Reader Core according to its configurations. The output is DC and requires a tone self-generating buzzer.

2.6.28 OSDP Ready

OSDP (Open Supervised Device Protocol) provides a secure, two-way communication protocol between peripheral devices (PD) such as an RFID reader and a Control Panel (CP). It is designed for access control purposes. Only power plus two serial lines are required to minimally connect the reader (reset is also recommended). This expands the capabilities of the reader greatly compared with the one-way Wiegand protocol and adds much greater security between the panel and the reader. RS-485 is generally used for the serial connection and the OMNIKEY SE Reader Core has a serial communications direction control pin to support this.

The OMNIKEY SE Reader Core has been designed to be OSDP ready. The USART interface is targeted as the OMNIKEY SE Reader Core to OSDP panel serial interface, and other OSDP related pins (2 x GPIO, nOSDP-TAMPER-IP, USART-RTS/DE) are provided on the serial port interface at P301 & P302. A direction control output is provided to allow the connection of an external half-duplex RS-485 buffer. The nOSDP-TAMPER-IP pin connects directly to the MCU, enabling the OMNIKEY SE Reader Core to generate an appropriate OSDP status response following a tamper event. The two GPIO pins can be designated as the general purpose OSDP input and output pins. The OSDP application is under development.

2.7 Performance optimization

The OMNIKEY SE Reader Core's configuration can affect the resultant performance (power consumption, time taken to complete operations, reliability of reading credentials). This section has some guidelines to help optimize performance.

2.7.1 Audio visual template configuration

The various firmware configurations possible for the OMNIKEY SE Reader Core include a group of settings to control the LED and buzzer outputs' behavior. This is called the "Audio Visual Template". By default, the OMNIKEY SE Reader Core will be configured to drive particular colors and buzzer indications at certain points of its operating cycle for certain periods. It is important to set the audio-visual template appropriately, as failure to do so may result in additional battery consumption or extended credential transaction timing while the OMNIKEY SE Reader Core is trying to assert an LED or buzzer which may or may not be present in the product.

Configurations are not currently available. Direct host to OMNIKEY SE Reader Core messaging can be used to manipulate the LEDs and buzzer.

2.7.2 Polling configuration

The OMNIKEY SE Reader Core can detect and read a wide range of different credentials, including HID Mobile Access credentials. To optimize its performance (both power and speed), ensure that it is configured to detect and read only credentials with which it is required to be used. The ability to work with an HID configuration card or application is essential and mandatory, so the ISO14443A protocol must not be disabled. For example, if only one type of LF credential is to be used, then disable the other types. If ISO15693 credentials are never used, then disable this protocol.

2.7.3 Credential detect (with BLE Advertising) state vs power

The credential detect and advertising state (i.e. BLE Advertising enabled) is low power, but still consumes more idle power than when BLE Advertising (a.k.a. BLE/BT Ping) is off. However, it can react more rapidly to start a BLE device transaction (compared with TAP mode - which uses the HF Ping to detect the mobile device) dependent upon the advertising rate set.

2.7.4 HID Mobile Access credential read performance

The read performance (transaction time, distance, reliability) of HID Mobile Access credentials may differ between makes and or models of mobile devices. There are two ways that the OMNIKEY SE Reader Core can detect the presence of a mobile device:

- Using the HF credential detect facility and detecting the mobile device by its effect.
- By a response to BLE Advertising by the OMNIKEY SE Reader Core.

The frequency of credential detect operations may differ from that of BLE Advertising.

Another factor is how and when the phone detects the reader, which decides when the phone can begin connecting to the reader, which is influenced by the phone antenna and processing performance. Different phones will have different operating behaviors and connection times. This is a result of different operating systems, different manufacturers, and different BLE chips on the phone. These factors are outside the HID's control.

Additionally, environmental factors may have an effect. Environments that have a lot of BLE devices in them will cause a higher variation in RSSI levels due to interference. There is also more chance of collisions on the advertising packets broadcast by the reader that are used by the phone to decide whether to connect. This may affect the user experience.

The OMNIKEY SE Reader Core can be customized to add or remove protocols or alter their relative priority. This may have some effect on when the BLE protocol is invoked and therefore on the system reaction times.

Transmit and RSSI fields parameters can be amended to improve/obstruct good connections.

Lastly, the phone must be presented for an adequate period to enable the mobile credential to be read.

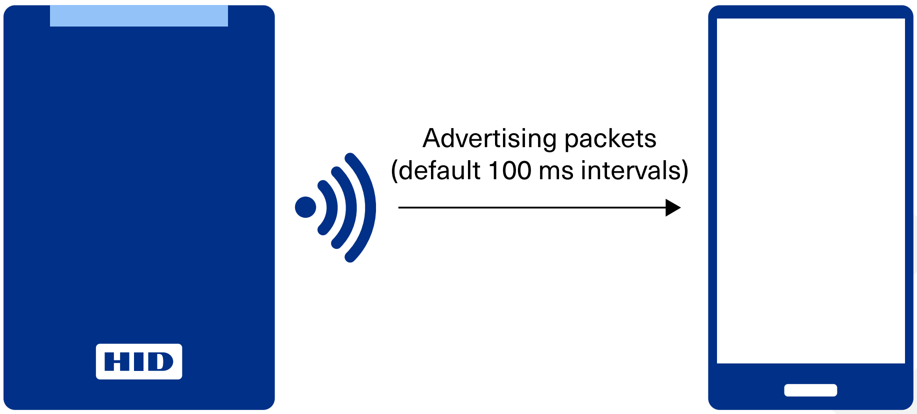
2.7.5 Credential presentation times and intervals

In credential-detect state, the OMNIKEY SE Reader Core uses an algorithm plus an external input (nEXT-WKUP-IN/PGDP) to decide if an HF/LF/NFC credential has been presented, or whether an external source is requesting that the OMNIKEY SE Reader Core wakes into normal power mode. After waking, credential polling for all configured protocols is performed and afterwards the OMNIKEY SE Reader Core goes back into credential-detect state and resumes credential operation. A credential must be presented for sufficient time to be read, and there is also an interval before the next credential can be read. In general, the better the reader indicates the start and/or end of credential reading to the user (e.g. by LED or buzzer activity) the more informed and predictable credential presentations will be for the user.

Physical detection (e.g. card, fob, tag)

There is a minimum interval between resuming credential-detect state and detecting the next credential presentation. Re-presenting a credential too soon after the OMNIKEY SE Reader Core has re-entered credential-detect state may impair or prevent its detection. This includes detecting the physical presence of mobile devices.

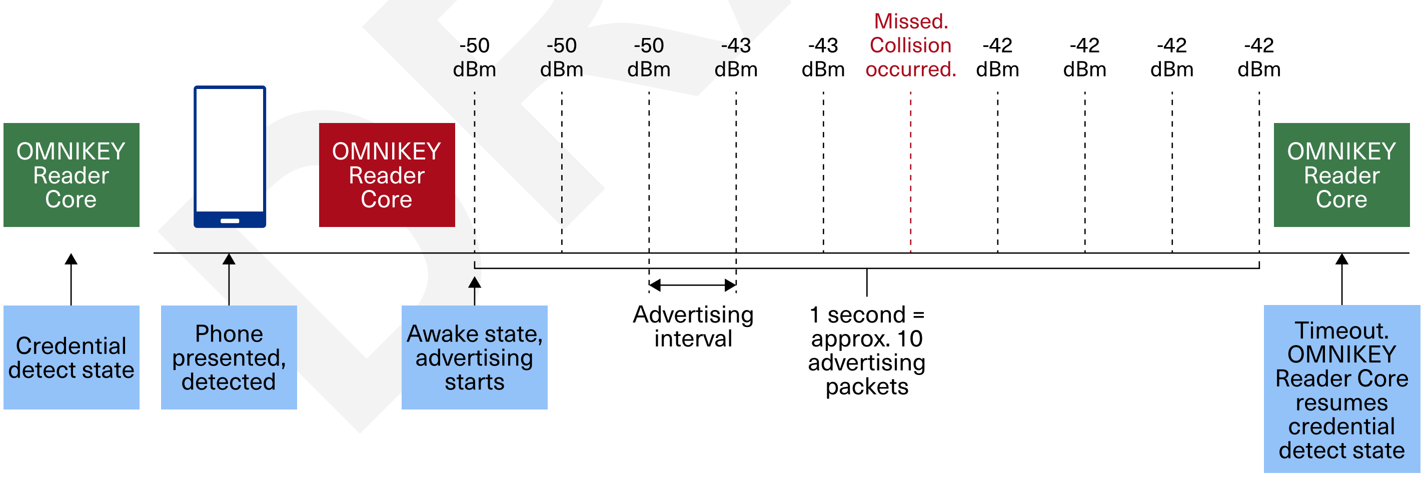
2.7.6 Description of detection



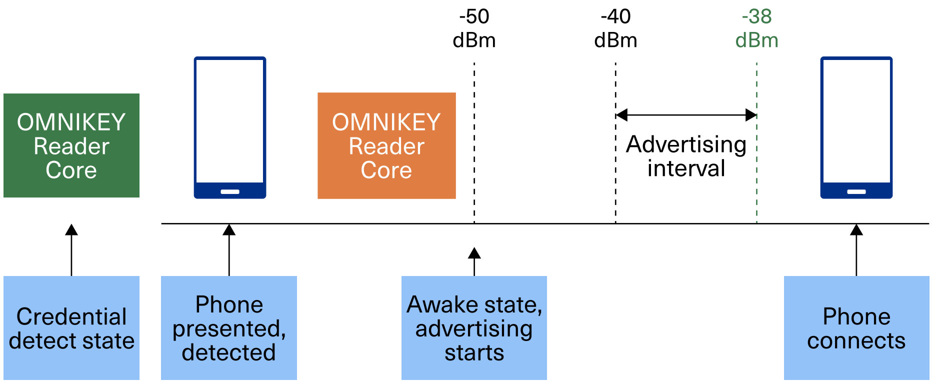
The phone looks for advertising packets from the reader and decides when to connect to it based on the signal strength (in lieu of distance) between the phone and the reader. The phone monitors the RSSI levels of the advertising packets until they are above the default of -40 dBm, then connects and starts a transaction.

> **Note:** There are some averaging algorithms on the phone as the RSSI values can vary for the same distance due to environmental factors.

Example 1: RSSI never gets low enough



Example 2: Good connection



2.7.7 Android BLE Scanning Abuse Prevention effect

Some Android OS devices, starting at Android 7.0 "Nougat", include a "BLE Scanning Abuse Prevention" measure. This prevents the HID Mobile Access application stopping and starting BLE scanning (e.g. looking for BLE advertisements from the OMNIKEY SE Reader Core) more than a few times (~5) within a short period (~30 seconds). This is not normally an issue but may become apparent when conducting product testing with Android mobile devices, for example when trying to read the mobile credential six times within 30 seconds. Care is needed to ensure a robust test procedure.

Secondly, long running scans by the BLE application (>30 minutes) will be converted into opportunistic scans. This means that the HID Mobile Access app will receive advertising packets only when another application, for example Google Play Services, is scanning at the same time. The HID Mobile Access application automatically resumes normal operation but may temporarily be in opportunistic scanning mode.

Both the above features are part of the Android OS and are not under the control of HID.

2.7.8 Mobile Media disconnect

At the time of writing, some Android phones do not disconnect in a timely manner when requested to do so.

The OMNIKEY SE Reader Core includes a timeout which forces a disconnect when it expires. However, in the meantime, the OMNIKEY SE Reader Core will remain active if the phone has failed to disconnect and will not revert to credential-detect operation until outside the timeout period. The normal disconnect sequence is as follows:

1. OMNIKEY SE Reader Core requests media disconnect.
2. Mobile device disconnects.

If the OMNIKEY SE Reader Core is being controlled in API mode, it is prudent to allow two seconds for a normal media disconnect operation to take place before any manual API command to put the OMNIKEY SE Reader Core back into the credential-detect state.

2.8 Low temperature operation

The OMNIKEY SE Reader Core does not include a secure element heater circuit. The OMNIKEY Secure Element uses different technology to the Mk2 iCLASS SE Reader Module and has a lower operating temperature limit of -25°C (-13°F) . There is no need to budget for the 75 mA additional current consumption that the MK2 iCLASS SE Reader Module heater circuit could require. Note that battery performance is usually impaired at low temperatures and batteries may last less time and have a lower voltage than when used in a warmer environment.

It is recommended that OMNIKEY SE Reader Cores used in environments that are at -25°C (-13°F) should have a permanent external power source and operate in a polling state, rather than be battery powered and using credential-detect state.

2.9 Transitioning to the OMNIKEY SE Reader Core from the SE32X0B Mk2 iCLASS SE Reader Module

Provided below are suggestions for transitioning to the OMNIKEY SE Reader Core from the Mk2 iCLASS SE Reader Module. The following differences should be noted:

- Previously unused pins on the 30-way expansion connector are now used and some pins that were for HID use only have been changed in function. These are backward compatible with the SE32X0B iCLASS SE Reader Module, though note that pin 8 "GND" has been changed to enable the 3V3-Direct scheme. Pin 8 was previously used only with the BT Xtender (which is no longer required). The three expansion pins EXP1,2,3 have been re-purposed. All pins are detailed in **3.5.6 P702 30-way board-to-board connector**.
- The maximum operating voltage for VDC is 6 V.
- The maximum height (and overall height) of the OMNIKEY SE Reader Core has decreased on the underside. See **4.2 OMNIKEY SE Reader Core heights (Z-dimension)**. It has a ~1 mm thick PCB (1.57 mm for the iCLASS SE Reader Module).
- When the external reset input nRST-IP is asserted (active low) power is immediately removed from the 3V3SW power domain for the duration of the reset assertion. The HF, LF and BLE interfaces are deactivated. Only the 3V3PERM domain components remain supplied. Credential detection is stopped. External wake-up detects are inactive.
- Solder hole interfaces are backward compatible both for usage and position and have additional connections available. See **4.6 HF and LF antenna interconnects**.
- For the OMNIKEY SE Reader Core Standard, the number of pins in the Picoblade connectors has increased (except the HF interface). Pre-existing connections are on the same pin number as before. Existing mating cable connectors with fewer connections will still fit but using a connector of the new width will be more secure. Unused signals do not have to be connected but having the metal inserts will increase the mechanical connection effectiveness.
- New firmware configuration items are now available to the user, via the OMNIKEY Reader Management application for PC, or the HID Reader Manager mobile application. These include:
  - Ping interval duration (the time between HF, LF or HF/LF pair, pings).
  - BLE advertising frequency.
- It is good practice to tie off the UART-RX input appropriately for your design to avoid a floating input.
- The OMNIKEY SE Reader Core MCU BOR circuit has a different threshold to those of the iCLASS SE Reader Module MCUs. See **Electrical specifications**.
- A DC/DC converter is used to power the HF and LF transmit interfaces. This has an undervoltage lock-out circuit built in. See **Electrical specifications**.
- Additional functionality includes both input and output circuits. Check which inputs have built-in tie-offs. See **Electrical specifications**.
- Two tamper input pins are provided. These can be left unconnected if unused. See **5.4.4 Tamper inputs**.
- The BT Xtender is not supported by the OMNIKEY SE Reader Core and is no longer needed. The GND pin of the Mk2 iCLASS SE Reader Module (not the VTRN pins) is used in the 3V3-Direct scheme as a 3V3-Direct enable input. Do **not** connect 3V3DIRECT-EN-IP to 0 V unless you are certain to use the 3V3-Direct powering scheme.
- 3V3PERM and 3V3AWAKE-OP are not designed to supply power to any user circuitry. 3V3AWAKE-OP is intended as an indication that the OMNIKEY SE Reader Core is awake. 3V3PERM will be used as a power supply input in the 3V3-Direct scheme (only).

2.10 OMNIKEY SE Reader Core integration checklist

The following checklist assists in design checking for OMNIKEY SE Reader Core implementations, including where a MK2 iCLASS SE Reader Module is being replaced. The checklist is not a substitute for reading this document or other good design practice.

Item	Description	Notes	Checked?
30-way connector	Some previously unused pins are now used.	Check pin usage.	
iCLASS SE Reader Module expansion port pins EXP1,2,3	No longer present.		
iCLASS SE Reader Module SAM heater	No longer present.	Check product operating temperature range/environment of use.	
BOR	BOR operating point has changed.		
DC/DC UVLO	The DC/DC converter has an undervoltage lockout.	The UVLO will cut all power to the 3V3PERM domain if triggered (normal power scheme). See 5.2 Operating characteristics.	
OMNIKEY SE Reader Core height	Overall height has decreased.	Check mechanical fit.	
Power supply	Check sufficient for all conditions, including a mild steel plate on the product antenna zone.	Minimum 350 mA suggested, 500 mA recommended.	
nRST-IP input		Drive with an open-collector/drain type output.	
Standard version connectors P301 & P701	These have additional pins, with a total of 15 pins each.	Adapt/check mating cables, connectors, and connections.	
Solder holes	Additional solder holes/signals added.	If required, increase the number of mating header pins as required.	
BLE	BLE support and U.FL BLE antenna connector now included.	Add BLE antenna and cable as required. Remove any BT Xtender module.	
3V3AWAKE-OP	Previously 3V3_HF or 3V3_RF. 3V3AWAKE-OP does not source power to any external circuit.	Additional circuitry must be powered by the host system.	
3V3PERM	Previously 3V3_PING. Does not source power to any external circuit (except older HF antennas).	Additional circuitry must be powered by the host system.	
3V3-Direct power scheme	Allows 3V3 to be used to power the OMNIKEY SE Reader Core.	See 3V3-Direct scheme connections. Choose power scheme. Connect 3V3DIRECT-IP(s), control 3V3DIRECT-EN-IP, connect VDC, as appropriate.	
BLED	Blue LED support has been added.	Allows additional color combinations.	
Tamper	nTamper and nMCU-Tamper input and nTamper-out output pins added.	See 5.4.4 Tamper inputs.	

Item	Description	Notes	Checked?
Antennas	Always check the loading from the antenna in-situ in the final product.	Check OMNIKEY SE Reader Core power consumption is <330 mA under all conditions.	
UART-RX Input	Drive or tie-off this input.	See 2.6.2 External resistors and UART RX & TX pins (UART-RX, UART-TX, P301, P302 and P702, P701, P703).	
Serial port flow/direction control signals	Configure and connect as required.	Refer to *OMNIKEY SE Reader Core User Guide* (PLT-06682)	
GPIO1,2	Configure and connect as required (future capability)	Refer to *OMNIKEY SE Reader Core User Guide* (PLT-06682)	
3V3DIRECT-EN-IP	Ensure that this pin is correctly driven, including at the 30-way connector.	Avoid accidentally connecting to GND/0 V due to a legacy BT Xtender design.	
Height	The OMNIKEY SE Reader Core has a reduced overall height and a thinner PCB compared with the iCLASS SE Reader Module.	Check that the reduced height/PCB thickness remains compatible with your design.	
PCB color	The OMNIKEY SE Reader Core PCB color is blue.	Update any documentation specifying the PCB color in relation to the iCLASS SE Reader Module.	

2.11 Anti-passback (Repeat Data Delay) [<<TBD>>Future capability]

See *OMNIKEY SE Reader Core Software Developer Guide* (PLT-0<<TBD>>Part? Will this be a reworking of SE3200-903 *iCLASS SE Reader Module Software Developer Guide*? for a full description of this feature.

A form of anti-passback (repeat data delay) is available in the OMNIKEY SE Reader Core. It prevents the repeated reporting of card CSN or access control application (PACS) data from the same credential within a programmable period, even if that credential is removed from the reader and then reappears. If the period is long enough, it can span across the presentation of a different credential between the first presentation and later presentation of the same credential, so the data is not repeated. This feature works in autonomous polling and also credential-detect state.

The period can be fixed or a "sliding" window which restarts the timer every time the repeated credential is presented.

True anti-passback is highly system dependent, according to the number and type of readers, entrance controls, and policies in use. For example, both entrance and exit readers may be necessary, or an enclosed entrance turnstile, or coordination across data from multiple readers.

2.12 Card tracking [<<TBD>>Future capability]

See *OMNIKEY SE Reader Core Software Developer Guide* (PLT-0<<TBD>>Part? See previous note. for a full description of this feature.

Card tracking is designed to track when a credential remains in the HF field of the OMNIKEY SE Reader Core and to not repeatedly report the card data.

If card tracking is enabled, card data will be reported only when a card enters the field and is not reported subsequently whilst the card is still in the field within a specified period. If this period expires, the card data will be reported again.

2.13 Using SE configuration cards

Configuration cards are used to change the configuration of the device, such as changing to new security keys for example. An SE configuration card uses the 13.56 MHz (HF) interface and the ISO 14443A protocol. It is implemented using a JCOP credential type. Different configuration cards take different periods to apply the configuration to the OMNIKEY SE Reader Core. This period could be as much as 10 to 20 seconds in some circumstances.

For enhanced security, SE configuration cards for the OMNIKEY SE Reader Core have different security keys than other pre-existing SE configuration cards (which can not be applied to the OMNIKEY SE Reader Core successfully).

The OMNIKEY SE Reader Core's LED and buzzer behavior in response to a configuration card is fixed <<TBD>>. If available, an amber LED color (i.e. red and green LEDs driven simultaneously) will be displayed during the reconfiguration, followed by beeper/buzzer activations, if available. Finally, the LED and buzzer activity will stop, although an anti-passback indication may be displayed whilst the card remains in the field.

It is important to leave the configuration card within read range until the configuration has ended. If the card is removed too soon, the OMNIKEY SE Reader Core will not accept a different type of configuration card until the first type has been re-presented and the configuration finished. After a successful configuration, if the same configuration card type is re-presented, it will not be reprocessed.

It is recommended that configuration card application is included in new product verification tests, to ensure that the product provides sufficient field strength, but not in production tests. Customers can request configuration cards from HID Global for this purpose.

2.14 Key loading and key-storage space

Configuration cards or management tools that load additional secure keysets into the OMNIKEY SE Reader Core, such as HID Mobile Access keys or HID Elite keys, require extra key-storage slots in the on-board secure element circuit. Key-storage slots are limited, and once used *cannot be reclaimed*. For this reason, it is recommended not to use Elite or Mobile key configuration cards except when needed, in the final product.

The OMNIKEY SE Reader Core has significantly increased secure storage space compared with the iCLASS SE Reader Module, allowing the security keyset to be changed multiple times. If key storage space is exhausted before a complete keyset is loaded, the OMNIKEY SE Reader Core operation may be compromised or blocked.

Customers can request key configuration cards for product development but should consider the information above. Re-configured prototypes should always be clearly labelled/logged.

Other configuration cards, such as those switching between configuring LEDs or buzzer or other similar functionality, do not affect key storage space.

Section 03

Connector configuration

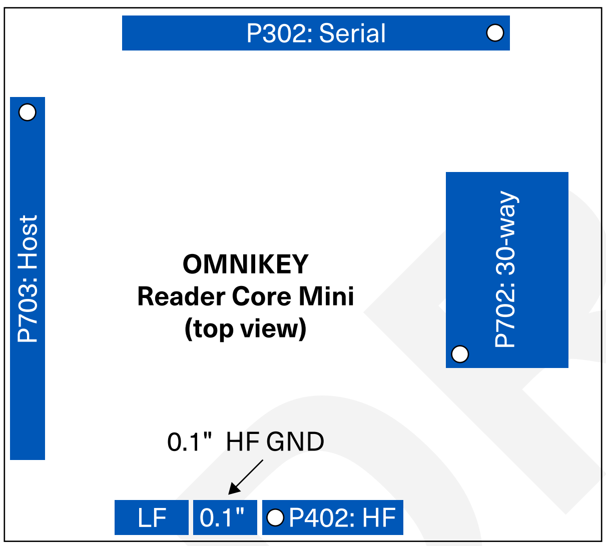
3.1 Introduction

There are two physical variations of the OMNIKEY SE Reader Core; Mini and Standard. The Standard version adds-wire-to-board two-part type connectors to the Mini version. For information about Alpha version devices, see **Alpha-version OMNIKEY SE Reader Core details**.

3.2 OMNIKEY SE Reader Core Mini connectors

The OMNIKEY SE Reader Core Mini connections are shown below.

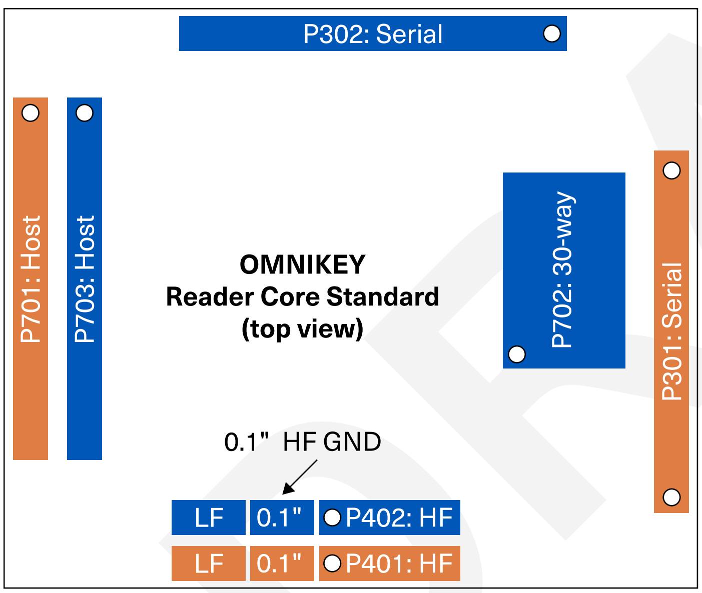
P302	Serial	Solder holes
P703	Host	Solder holes
P702	30-way	Board to board
P402	HF	Solder holes
E501,2	LF	Solder holes
GND (E503)	0.1" 0 V for HF antenna	For when a 0.1" pitch header is used between from the host PCB to the OMNIKEY SE Reader Core for HF connections.



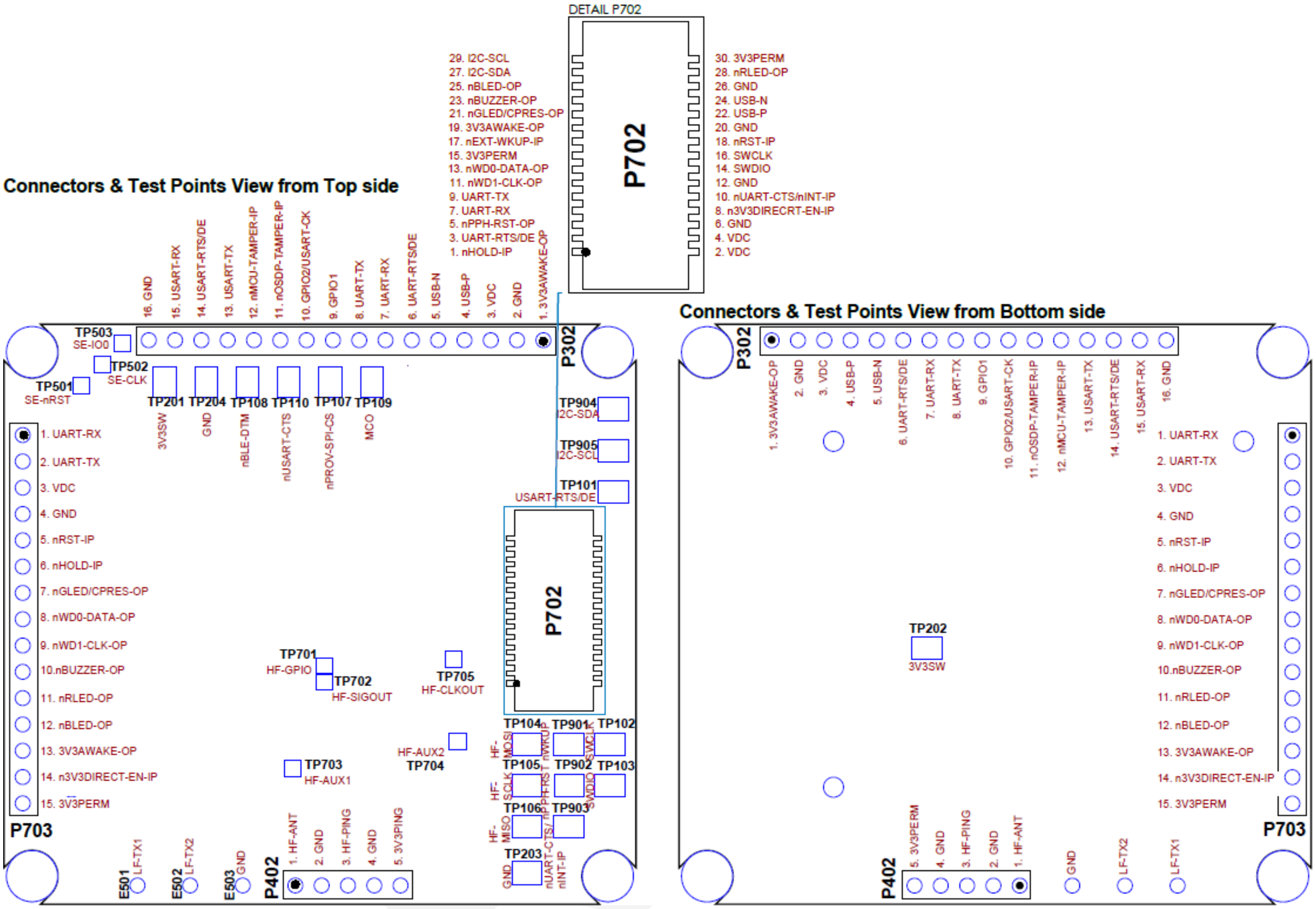
3.3 OMNIKEY SE Reader Core Standard connectors

The OMNIKEY SE Reader Core Standard connections are shown below.

P302	Serial	Solder holes
P301	Serial	Picoblade connector
P703	Host	Solder holes
P701	Host	Picoblade connector
P702	30-way	Board to board
P402, P401	HF	Solder holes
P401	HF	Picoblade connector
E501, E502, E501', E502'	LF	Solder holes
GND (E503)	0.1" 0 V for HF antenna	For when a 0.1" pitch header is used between from the host PCB to the OMNIKEY SE Reader Core for HF connections.



3.4 OMNIKEY SE Reader Core Mini port signals



3.5 OMNIKEY SE Reader Core Standard port signals

The OMNIKEY SE Reader Core Standard connector pin allocation is detailed below.

3.5.1 P301 serial connector (Picoblade 15-way)

This connector is compatible with the SE32X0B iCLASS SE Reader Module connector, but with additional signals added at one end. The UART-RX and UART-TX signals are now also connected to P703 and P701; this means that only one connection to P703 (or P701) is needed to connect to all the functional signals provided previously (by the Mk2 and Rev-A iCLASS SE Reader Module) across P703/P302, reducing the number of headers (or cables for the Standard version) by one thus simplifying and reducing the cost of connecting to the OMNIKEY SE Reader Core.

Pin	Signal name	Type	Function
1	3V3AWAKE-OP	Output	0.1 W maximum power sourced output
2	GND	Supply 0 V	Power supply return (including for USB)
3	VDC[1,2]	Supply voltage	USB 2.0 Full speed interface
4	USB-P	USB data line	
5	USB-N	USB data line	
6	UART-RTS/DE	Output	UART RTS / DE (Direction Enable)
7	UART-RX	Input	UART data in
8	UART-TX	Output	UART data out
9	GPIO1	I/O (as configured)	
10	GPIO2/USART-CK	I/O (as configured)	
11	nOSDP-TAMPER-IP	I/P, I/O (as configured)	A wake-up pin, capable of waking up the OMNIKEY SE Reader Core from the credential detect states
12	nMCU-TAMPER-IP		A wake-up pin, capable of waking up the OMNIKEY SE Reader Core from all states, with dedicated tamper functionality.
13	USART-TX		
14	USART-RTS/DE		USART RTS / DE (Direction Enable)
15	USART-RX	I/P with pull-up	

1. The external power supply connections or polarity to the OMNIKEY SE Reader Core must never be reversed, as doing so will quickly cause permanent damage and prevent the OMNIKEY SE Reader Core from operating.
2. VDC is VUSB when this port is used as the USB interface.

3.5.2 P302 serial connector (solder holes)

This connector is compatible with the SE32X0B iCLASS SE Reader Module connector, but with additional signals added at one end. The UART-RX and UART-TX signals are now also connected to P703 and P701. This means that only one connection to P703 (or P701) is needed to connect to all the functional signals provided previously (by the Mk2 and Rev-A iCLASS SE Reader Module) across P703/P302, reducing the number of headers (or cables for the Standard version) by one, thus simplifying and reducing the cost of connecting to the OMNIKEY SE Reader Core.

Pin	Signal name	Type	Function
1	3V3AWAKE-OP	Output	0.1 W maximum power sourced output
2	GND	Supply 0 V	Logic level reference
3	VDC	Supply voltage (VUSB)	USB 2.0 Full Speed interface
4	USB-P	USB data line	
5	USB-N	USB data line	
6	UART-RTS/DE	O/P	For UART flow control, including direction control of an external Half duplex bidirectional buffer (e.g. RS485 drivers).
7	UART-RX[1]	I/P	UART data in
8	UART-TX	O/P	UART data out
9	GPIO1	I/O (as configured)	
10	GPIO2/USART-CK	I/O (as configured)	
11	nOSDP-TAMPER-IP	I/P, I/O (as configured)	A wake-up pin, capable of waking the OMNIKEY SE Reader Core from the credential detect states
12	nMCU-TAMPER-IP	I/P	A wake-up pin, capable of waking the OMNIKEY SE Reader Core from all states, with dedicated tamper functionality.
13	USART-TX	O/P	Unbuffered
14	USART-RTS/DE	O/P	For USART flow control, including direction control of an external half-duplex bidirectional buffer (e.g. RS485 drivers).
15	USART-RX	I/P with pull-up	
16	GND		

1. UART-RX must be connected appropriately. See **2.6.1 Power supply (VDC, GND)**. The external power supply connections or polarity to the OMNIKEY SE Reader Core must never be reversed, as doing so will quickly cause permanent damage and prevent the OMNIKEY SE Reader Core from operating.

3.5.3 P301 & P302 connections: OMNIKEY SE Reader Core to SE32X0B comparison

The connections shown below have changed or been added. Changed connections use previously reserved or unused ports. Added connections are in addition to the ports of the iCLASS SE Reader Module Mk2.

Pin	OMNIKEY SE Reader Core	SE32X0B Reader Core	Notes
1	3V3AWAKE-OP[1]	3V3_HF	No longer a power output. Renamed from 3V3_HF. Remains a switched output, active when OMNIKEY SE Reader Core is awake.
2	GND	GND	Previously named VRTN. Connect to host 0 V as before, including USB 0 V.
3	VDC	Exp-1	Now VDC. Can be used to connect USB 2.0 VBUS supply.
4	USB-P	Exp-2	Now USB data signal
5	USB-N	Exp-3	Now USB data signal
6	UART-RTS/DE	Do not connect	Now UART-RTS/DE
7	UART-RX	Same	Same
8	UART-TX	Same	Same
9-15	New connections	N/A	See 3.5.2 P302 serial connector (solder holes) and 3.5.1 P301 serial connector (Picoblade 15-way)
16	GND (new) P302 only	N/A	P302 only. Not present on P301 in OMNIKEY SE Reader Core Standard.

1. One application of this output is to monitor the operational state of the OMNIKEY SE Reader Core while operating in credential detection state.

3.5.4 P703 host connector (solder holes)

This connector is compatible with the SE32X0B iCLASS SE Reader Module connector. Additional connections have been added at both ends when compared with the SE32X0B. Pin 3 is in the same location as pin 1 of the SE32X0B Reader Module. Pins 3 - 11 have the same functions, in the same order, as pins 1 - 9 of the SE32X0B iCLASS SE Reader Module.

Note that P703 now includes all the functionality from both P703 & P302 in the SE3210B devices. This means that only one connector is needed in place of the two previously (for the same functionality) and this can include blue LED activation and/or the 3V3-Direct power scheme as well.

Pin	Signal name	Type	Function
1	UART-RX		UART receive input (general use plus use for OSDP Panel communication).
2	UART-TX		UART transmit output (general use plus use for OSDP Panel communication).
3 (old pin 1)	VDC	Supply	Supply voltage positive.
4	GND (formerly VRTN)	Supply	Supply voltage negative.
5	nRST-IP	Input, pull-up	Reset (active low). Resets the OMNIKEY SE Reader Core whilst asserted.
6	nHOLD-IP	Input, pull up	Holds off the output of the card data to the host (regardless of host channel connection). When asserted, either buffers the last card data and/or disables a card read until released, as configured.
7	nGLED/nCPRES-OP	Output, open collector	Green LED enable output (active low) & Card Present signal (active low). nCPRES is active when card data is sent to the host in Autonomous mode via the configured host interface(s).
8	nWD0-DATA-OP	Output, pull-up	Wiegand Data 0. Outputs card data as Wiegand format bits, as configured.
9	nWD1-CLK-OP	Output, pull-up	Wiegand Data 1. Outputs card data as Wiegand format bits, as configured.
10	nBUZZER-OP	Output, open collector	Buzzer enable output (active low). Activated according to configuration.
11 (old pin 9)	nRLED-OP	Output, open collector	Red LED enable output (active low). Activated according to configuration.
12	nBLED-OP	Output, open collector	Blue LED enable output (active low). Activated according to configuration.
13	3V3AWAKE-OP		Active high. A logical indication that the OMNIKEY SE Reader Core has entered its active state and has turned on the 3V3RF supply domain for credential reading. This is not a power output.
14	n3V3DIRECT-EN-IP	Input with pull-up	Normal power scheme: Tie to VDC (preferred) or leave unconnected if VDC is unavailable. 3V3-Direct scheme: Tie to GND/0 V if the 3V3-Direct scheme is required.
15	3V3DIRECT-IP	Supply input for 3V3DIRECT	Normal power scheme: Leave unconnected. 3V3-Direct power scheme: Use as an additional VDC input (VDC at 3.3 V).

3.5.5 P701 host connector (Picoblade 15-way, OMNIKEY SE Reader Core Standard only)

This connector is functionally referenced with the SE3210B Reader Module connector. Functions on pins 1-9 remain compatible with the SE3210B iCLASS SE Reader Module family. Additional connection pins 10-15 have been added. Pin 1 is in the same physical location as pin 1 of the SE32X0B iCLASS SE Reader Module.

Note that P701 now includes all the functionality from both P701 & P301 in the SE3210B devices. This means that only one cable/connector is needed in place of the two previously (for the same functionality), and this can include blue LED activation &/or the 3V3-Direct power scheme as well.

Pin	Signal name	Type	Function
1	VDC	Supply	Supply voltage positive
2	GND (formerly VTRN)	Supply	Supply negative
3	nRST-IP	Input, pull-up	Reset (active low). Resets the OMNIKEY SE Reader Core whilst asserted.
4	nHOLD-IP	Input, pull up	Holds off the output of the card data to the host (regardless of host channel connection). When asserted, either buffers the last card data and/or disables a card read until released, as configured.
5	nGLED/nCPRES-OP	Output, open collector	Green LED enable output (active low) & Card Present signal (active low). nCPRES is active when card data is sent to the host in Autonomous mode via the configured host interface(s).
6	nWD0-DATA-OP	Output, pull-up	Wiegand Data 0. Outputs card data as Wiegand format bits, as configured.
7	nWD1-CLK-OP	Output, pull-up	Wiegand Data 1. Outputs card data as Wiegand format bits, as configured.
8	nBUZZER-OP	Output, open collector	Buzzer enable output (active low). Activated according to configuration.
9	nRLED-OP	Output, open collector	Red LED enable output (active low). Activated according to configuration.
New functions			
10	nBLED-OP	Output, open collector	Blue LED enable output (active low). Activated according to configuration.
11	UART-RX	Input	UART receive input
12	UART-TX	Output	UART transmit output
13	3V3AWAKE-OP		Active high. A logical indication that the OMNIKEY SE Reader Core has entered its active state and has turned on the 3V3RF supply domain for credential reading. This is not a power output.
14	n3V3DIRECT-EN-IP	Input with pull-up	Normal power scheme: Tie to VDC (preferred) or leave unconnected if VDC is unavailable. 3V3-Direct scheme: Tie to GND/0 V if the 3V3-Direct scheme is required.
15	3V3DIRECT-IP	Supply input for 3V3DIRECT only	Normal power scheme: Leave unconnected. 3V3-Direct power scheme: Use as an additional VDC input (VDC at 3.3 V).

3.5.6 P702 30-way board-to-board connector

This connector is an alternative interconnection method to P301 and P701. The connector is backward compatible with the SE32X0B Reader module connector, except for the new usage of the EXP1,2,3 pins and the use of some previously reserved pins. Already existing signals remain on the same pin as before. It should be possible to plug this connector/OMNIKEY SE Reader Core directly into a design that previously held the iCLASS SE Reader Module MK2 via its 30-way connector. RFU = Reserved for future use. Consult HID.

Pin	Signal	Type	Note	Pin	Signal	Type	Note
1	nHOLD-IP	Input	Active low, with pull-up	2	VDC	Input supply	Power supply Positive input
3	UART-RTS/DE	Input	UART RTS output / external serial data buffer direction control output for half duplex communications.	4	VDC	Input supply	Power supply Positive input
5	nPPH-RST-OP	Output	Used to reset an external circuit. Requires external pull-up if used.	6	GND (formerly VRTN)	Supply return	Power supply negative return
7	UART-RX[1]	Input with pull-up	UART Receive	8	n3V3DIRECT-EN-IP	Input with pull-up	Tie to VDC (preferred) or leave unconnected if the normal power scheme is required. Tie to GND/0 V if the 3V3-Direct scheme is required.
9	UART-TX	Output	UART Transmit	10	nUART-CTS/ nINT-IP	Input with pull-up	UART nCTS input. / Interrupt input. Active low.
11	nWD1-CLK-OP	Output with pull-up	Wiegand Data 1/Clock	12	GND (formerly VRTN)	Supply return	Power supply negative return.
13	nWD0-DATA -OP	Output with pull-up	Wiegand Data 0/Data	14	SWDIO	I/O	Main MCU programming. HID only.
15	3V3DIRECT-IP	Power Supply	Only for 3V3-Direct scheme, tie to VDC. Otherwise leave unconnected.	16	SWCLK	Input	Main MCU programming. HID only.
17	nEXT-WKUP- IP	Input with pull-up	Active-low external wake-up input	18	nRST-IP	Input with weak pull-up	Active-low OMNIKEY SE Reader Core reset input
19	3V3AWAKE-OP	Output	Indicates that the MCU is AWAKE, and reflects the value of the 3V3-DIG supply	20	GND (formerly VRTN)	Supply return	Power supply negative return
21	nGLED/nCPRES -OP	Output (O/C)	Active-low green LED enable/Card Present signal	22	USB-P	Input	USB positive data line

Pin	Signal	Type	Note	Pin	Signal	Type	Note
23	nBUZZER-OP	Output (O/C)	Low buzzer o/p	24	USB-N	Input	USB negative data line
25	nBLED-OP	Output (O/C)	Active-low blue LED o/p	26	GND (formerly VRTN)	Supply return	Power supply negative return
27	I2C-SDA	I/O with pull-up	I2C data line for expansion circuit.	28	nRLED-OP	Output (O/C)	Active-low red LED o/p
29	I2C-SCL	I/O with pull-up	I2C clock line for expansion circuit.	30	3V3DIRECT-IP	Power supply	**Only** for 3V3-Direct scheme, tie to VDC. Otherwise leave unconnected.

1. UART-RX must be connected appropriately. See **2.6.1 Power supply (VDC, GND)**. The external power supply connections or polarity to the OMNIKEY SE Reader Core must never be reversed, as doing so will quickly cause permanent damage and prevent the OMNIKEY SE Reader Core from operating. See **2.6.2 External resistors**.

3.5.7 P401, P402 HF antenna connector

The HF antenna connection is compatible with the SE32X0A and SE32X0B iCLASS SE reader module antennas. It includes the ping / credential detect connections. Do not invoke HF RFID operations without an HF antenna fitted; doing so can result in higher current consumption.

See section 4.4 HF and LF antenna interconnects regarding an additional single connector/cable method of connecting to an HF/LF antenna pair.

OMNIKEY SE Reader Core antenna connector (P401, P402) pin definitions

P401	Signal name	Type	Function
1	HF-ANT	Output	13.56 MHz antenna carrier drive signal (previously named ATX)
2	GND	Reference	Antenna ground reference
3	HF-PING	Output	Signals for credential detection
4	GND	Reference	
5	3V3PERM	DC Output	

> **Note:** For reference purposes, the SE32X0A Reader Module antenna connections are shown below.

3.5.8 E501/E502 Prox Antenna connector

Pin	Signal name	Type	Function
E501	LF-TX1	Output	125 kHz antenna driving signal
E502	LF-TX2	Output	

3.5.9 E503 HF Antenna 0.1" GND connector

Pin	Signal name	Type	Function
E503	HF Antenna 0.1" GND	Supply return	Use to connect to the GND return of the HF antenna interface when using a 0.1" pitch header to connect the HF (and optionally LF) antenna interface directly to a host board.

3.5.10 Test points

Test points are used in production of the OMNIKEY SE Reader Core and for debug and development by HID Global. Do not connect to any test point unless advised to do so by HID Global.

P401	Signal name	Type[1]	Notes
TP101	USART-RTS/DE	O/P	
TP102	SWCLK	I/P	
TP103	SWDIO	I/O	
TP104	HF-MOSI	I/O	
TP105	HF-SCLK	O/P	
TP106	HF-MISO	I/O	
TP107	nPROV-SPI-CS	I/P	
TP108	nBLE-DTM	I/O	
TP109	MCO	I/O	
TP110	USART-CTS	I/O	
TP201	3V3SW	Supply indication	
TP202	3V3SW	Supply indication	Can be used to check the level of the internal power supply rail during integration of the OMNIKEY SE Reader Core with external hardware. Normal supply scheme: This is a regulated voltage - 3.3 V nominal. 3V3-Direct scheme: This is the externally supplied 3V3 voltage.
TP203	GND	GND	
TP204	GND	GND	
TP501	SE-nRST	I/O	
TP502	SE-CLK	I/O	
TP503	SE-IO0	I/O	
TP701	HF-GPIO	O/P	
TP702	HF-SIGOUT	O/P	
TP703	HF-AUX1	I/O	
TP704	HF-AUX2	I/O	
TP705	HF-CLKOUT	O/P	
TP901	nEXT-WKUP-IP	I/P	
TP902	nPPH-RST-OP	O/P	
TP903	nUART-CTS/nINT-IP	I/P	
TP904	I2C-SDA	I/O	
TP905	I2C-SCL	I/O	

1. Type indicates the native type of the OMNIKEY SE Reader Core signal, before any external circuit is attached.

Section 04

Mechanical specifications

4.1 Introduction

The following section details the mechanical specifications for the OMNIKEY SE Reader Core and its connectors. Detailed drawings and a 3D .STEP model are also available on the HID Developer Portal. The 3D model uses manufacturers' data and may show typical component heights, not maximal component heights. Note the tolerancing information on the provided drawings. Information about selected components height is provided in this section.

4.2 OMNIKEY SE Reader Core heights (Z-dimension)

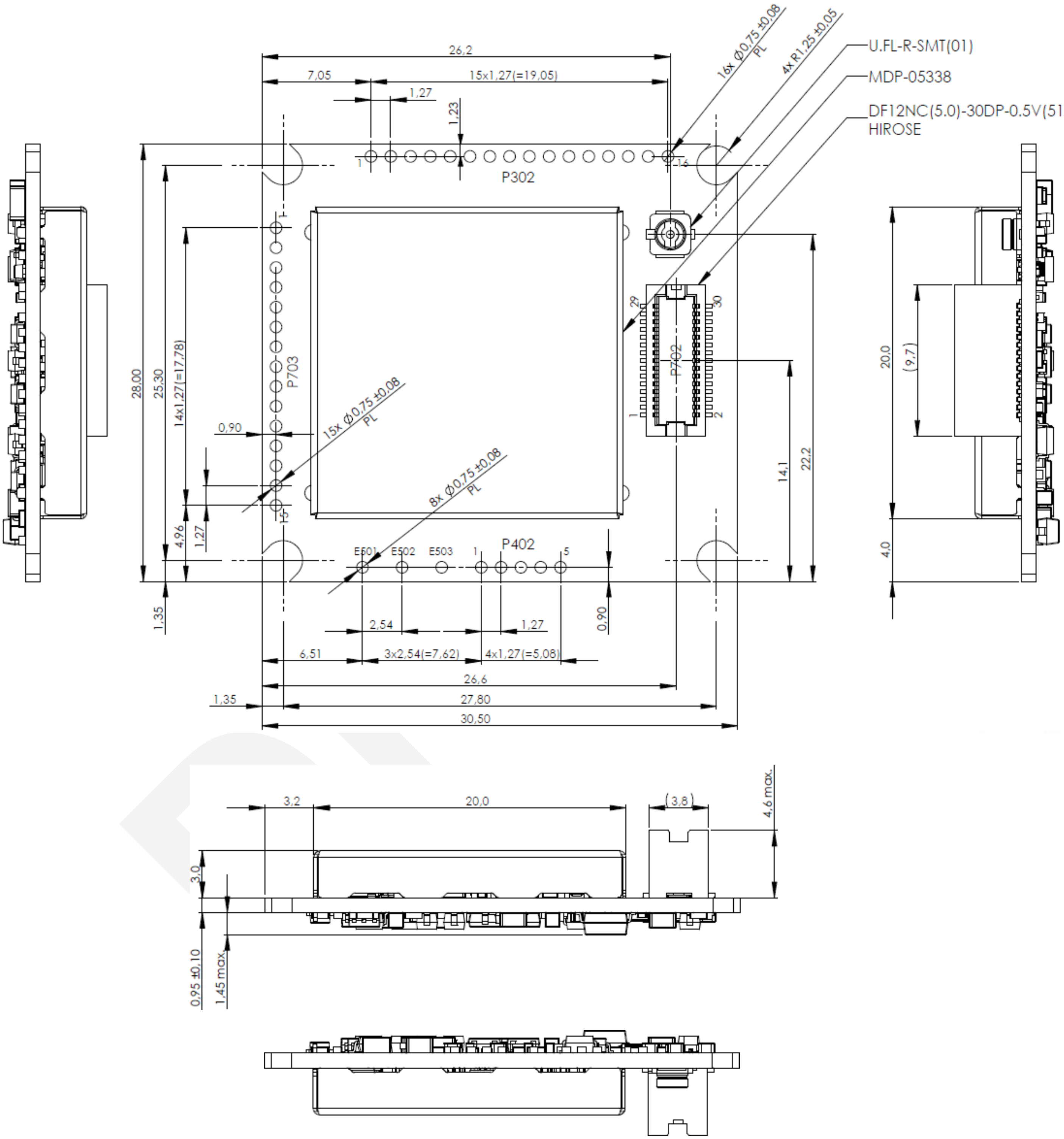
Note: OMNIKEY SE Reader Core nominal PCB thickness is reduced to 0.95 mm (was 1.57 mm for iCLASS SE Reader Module).

	Maximum height of components on OMNIKEY SE Reader Core underside[1]	Maximum overall height[1 3]
RCS55100000 OMNIKEY SE Reader Core Mini	1.45 mm including solder	7.1 mm including solder
RCL55100000 OMNIKEY SE Reader Core Standard	1.95 mm[2] including solder	7.4 mm including solder
SE32X0B Reader Module MK2	3.3 mm	~8.87 mm
SE32X0A Reader Module Rev A	2.182 including solder	~7.97 mm

1. Effects of solder height and conformal coating not included unless otherwise stated. PCB thickness at maximum tolerance.
2. Includes protrusion of maximum tolerance Picoblade connector leg, with minimum tolerance PCB thickness.
3. Maximum PCB thickness tolerance used.

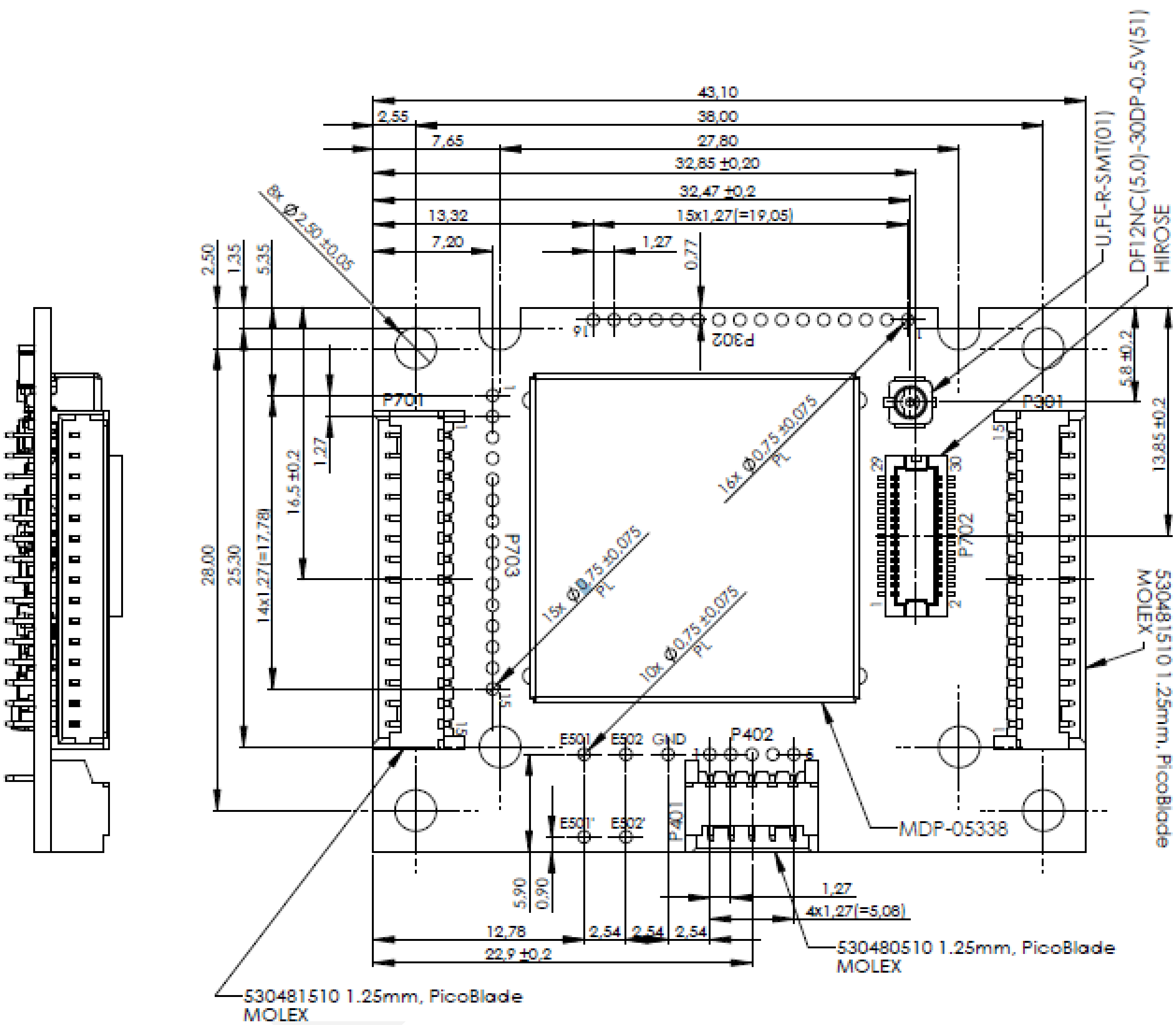
4.3 RCS55100000 (OMNIKEY SE Reader Core Mini)

This form factor is compatible with the SE3200B MK2 iCLASS SE Reader Module, with a reduced overall height.

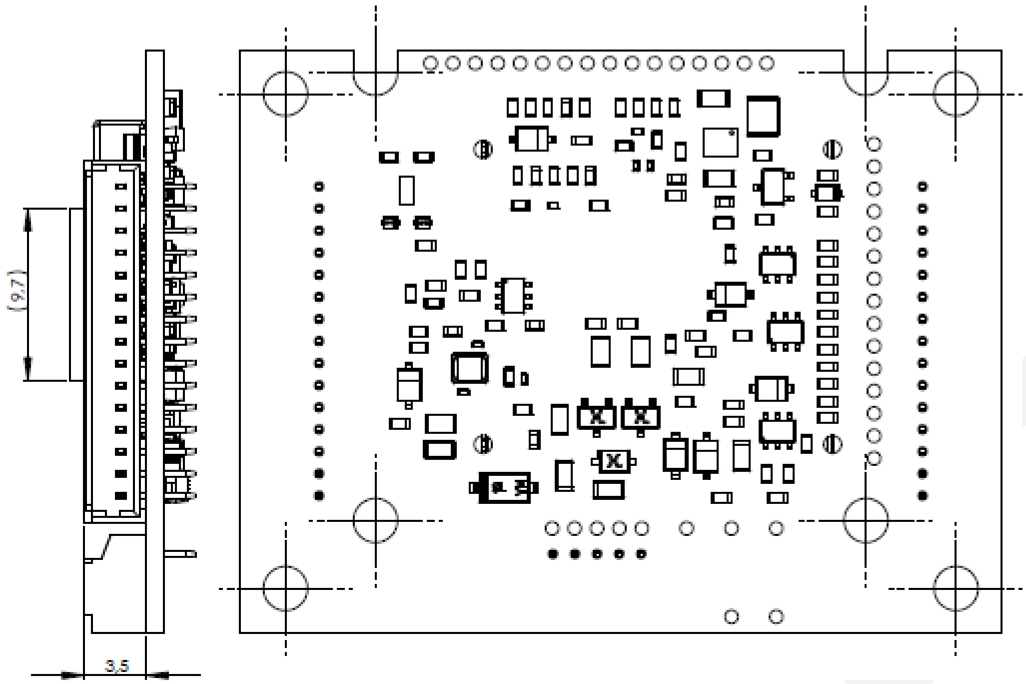


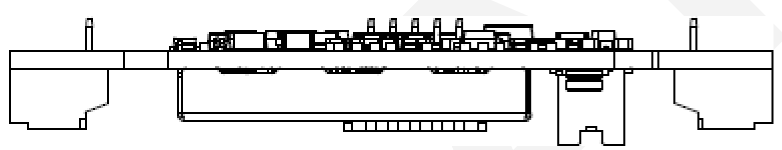
4.4 RCL55100000 (OMNIKEY SE Reader Core Standard)

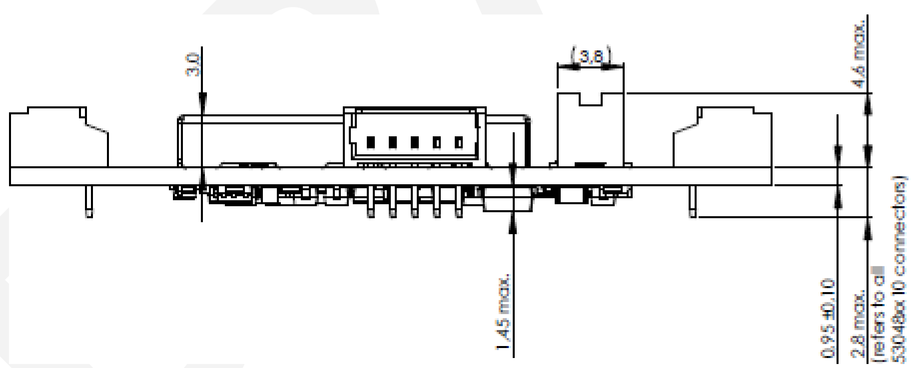
This form factor is volume compatible[1] with the SE3210B Reader Core with less volume overall and a reduced height. Two Picoblade connectors are now extended to 15 pins (the host and serial ports). Check that the body of these connectors will fit in your application. The Standard version has the same X and Y dimensions, placement of mounting holes, 30-way connector, pre-existing solder holes, and HF connector as the Mini version and the Mk2 iCLASS SE Reader Module.



1. Volume being the cuboid formed by the maximum X, Y, Z dimensions.


(9,7)
3,5




3,0
(3,8)
4,6 max.
1,45 max.
0,95 ±0,10
2,8 max.
(refers to all
53048xx10 connectors)

4.5 Connector types

4.5.1 RCx55100000 connector types

The following connectors are used for interconnection with host and antennas.

Connector	Function	Type/counterpart	
P301	Serial interfaces (15-way)	Manufacturer: Type: Part number: Mates with:	Molex PicoBlade 53048-1510 Molex 05102 series
P701	Host interfaces (15-way)	Manufacturer: Type: Part number: Mates with:	Molex PicoBlade 53048-1510 Molex 05102 series
P702	30-way. Alternative connection to P301 and P702	Manufacturer: Type: Part number: Mates with:	Hirose Electric Board to board DF12D(5.0)-30DP-0.5 VDC DF12-30DS-0.5V(86)
P401	HF antenna (5-way)	Manufacturer: Type: Part number: Mates with:	Molex PicoBlade 53048-0510 Molex 05102 series
E501/E502	Prox antenna	Direct solder to OMNIKEY SE Reader Core - no connector. It is recommended that the Prox antenna is strain relieved by applying epoxy to adhere the antenna leads to the OMNIKEY SE Reader Core for non-potted integrations. Indirect connection to another board (itself holding the LF antenna) via a 2-way 6.45 mm (0.254") pitch connector or a 6-way 6.45 mm (0.254") pitch connector for a compatible dual HF/LF antenna pair board. See 4.6 HF and LF antenna interconnects.	
CON101	BLE antenna cable socket	Manufacturer: Type: Part number: Mates with:	Hirose U.FL surface mount. 50 ohms. Vertical. U.FL-R-SMT-1(<packaging code>) Example: Hirose U.FL-LP-0<height & cable height code>HF

Note: Other manufacturers have connector systems with Picoblade-like compatibility. Examples include Amphenol & TE Connectivity 1.25 mm series.

4.5.2 RCx55100000 solder holes pitch and size

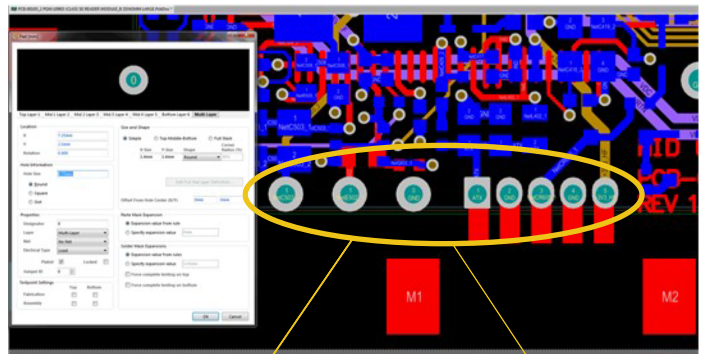
P302, P402, P703, and E501, E502, E503 are all compatible with 1.25 mm (0.049") or 1.27 mm (0.050") pitch connectors. The drill-hole size is 0.75 mm (0.029"). Many compatible 1.27 mm (0.050") pitch connectors are available from multiple sources. One 1.25 mm (0.049") header source is Cherng Weei Technology Corp (www.cwe.com.tw).

Part drawings are available on the HID Developer Portal.

4.6 HF and LF antenna interconnects

4.6.1 HF antenna interface solder holes - P402

The HF antenna interface solder holes on the OMNIKEY SE Reader Core are compatible with 1.25 mm/0.049" pitch and 1.27 mm/0.050" pitch systems with suitable diameter pins. The drill hole size is 0.75 mm (0.029").



4.6.2 LF antenna interface solder holes - E501,2

The LF antenna interface solder holes are aligned with the HF antenna interface solder holes and are compatible with a 2.54 mm (0.1") pitch connector. The most common LF connection method is to directly solder the LF antenna coil tails to the OMNIKEY SE Reader Core board.

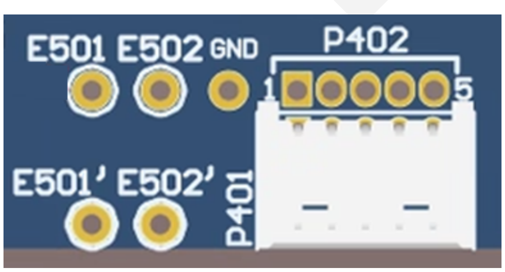
4.6.3 Combined LF and HF antenna solder hole connection, single connector option - E503

E503 (GND) is a solder hole connected to the OMNIKEY SE Reader Core GND return, located between the LF and HF antenna interface solder holes, on a 2.54 mm (0.1") pitch. This means that if required, a user can use a single 6-way 2.54 mm (0.1") pitch connector or single cable to connect both the LF and HF antennas to the OMNIKEY SE Reader Core. The HF interface connects on pins 1, 3 and 5 only when a 2.54 mm (0.1") pitch connector is used, and the additional GND connection E503 is essential in that usage.

Note: The drill hole size is 0.75 mm (0.029") so a suitable pin diameter connector is required to take advantage of this option. One option may be to use a depopulated 11-way (pins 1, 3, 5, 7, 9, 11 remain populated) 1.27 mm (0.050") pitch connector.

4.6.4 OMNIKEY SE Reader Core Standard LF antenna solder holes - E501' and E502'

E501 and E502 LF antenna solder holes are duplicated (and connected) in the OMNIKEY SE Reader Core Standard (as E501' and E502') positioned to the left of the HF antenna connector and close to the edge of the board. This is to allow the HID HF/LF antenna LF cable to be soldered more easily to the OMNIKEY SE Reader Core Standard with minimal distortion of the HF cable. E503 (shown as GND) is not duplicated as it is not needed in this scenario (pins 2 and 4 of the P401 Picoblade connector provide the GND connection).



Section 05

Electrical specifications

5.1 Absolute maximum ratings

Stresses beyond those listed may cause permanent damage to the device. This is a stress rating and functional operation of the device at these or other conditions (beyond those indicated in the operational sections) is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability. Note that voltage ratings shown below *already* include margins applied during testing for UL recognition and are absolute maximum ratings.

Operating temperature	-25°C to 65°C (-13°F to149°F)
Storage temperature	-45°C to 85°C (-49°F to 185°F)
Operating voltage range (normal supply)	3.3 to 6.5 VDC
Operating voltage range (3V3-Direct supply)	3.0 to 3.6 VDC
Weight: RCS55100000	Typical: ~8.0 g
Weight: RCL55100000	Typical: 9 g

5.2 Operating characteristics

For additional information see **5.11 Host power supply levels, indications and management** for essential notes concerning the host system power supply behavior and management. All measurements used standard HID antennas in free air[1]. Values are over the -25°C to +70°C temperature range unless otherwise specified.

Parameter	Description		Min.	Typ.	Max.	Unit
VDC-norm	Input voltage RCx55100000 (normal powering scheme).		3.5		6	VDC
VDC-dir	Input voltage RCx55100000 (3V3-Direct scheme only).		3.1	3.3	3.5	VDC
VDC-rise	Vdc rise rate to ensure internal power-on reset signal of wake-up microcontroller.					V/ms
Idc-pl	Current consumption in Autonomous Mode, normal power scheme, HF & LF enabled.	Vdc=3.6 V				mA
		Vdc=6 V				
Idc-cd-norm	Current consumption in credential detect state (HF and LF pinging), free air, separated antennas or HF/LF dual antenna, normal power supply scheme.	Vdc=3.6 V				µA
		Vdc=6 V				
Idc-cd-dir	Current consumption in credential detect state (HF and LF pinging), free air, separated antennas or HF/LF dual antenna, 3V3-Direct supply scheme.					µA
Idc-sh	Current consumption in SHUTDOWN mode, free air, separated antennas or HF/LF dual antenna. Normal power supply scheme. Vin=3.6 V.					µA
Idc-sp-sa	Current consumption with steel plate or high load credential 3 mm above and coaxial with HID small HF antenna, free air, 20°C, continuous carrier[2] Normal power supply scheme.				See note[4]	mA
Idc-sp-hl	Current consumption with steel plate or high load credential 3 mm above and coaxial with HID HF/LF antenna, free air, 20°C, continuous carrier[2]				See note[4]	mA
MCU- BOR3[3]	MCU brown-out reset activation threshold 3 - rising edge		2.56	2.61	2.66	V
	MCU brown-out reset activation threshold 3 - falling edge		2.47	2.52	2.57	V
MCU- BOR0[3]	MCU brown-out reset activation threshold 0 - rising edge		1.62	1.66	1.70	V
	MCU brown-out reset activation threshold 0 - falling edge		1.60	1.64	1.69	V
DC/DC UVLO[4]	DC/DC regulator under voltage lock out threshold - rising			2.06	2.14	V
	DC/DC regulator under voltage lock out threshold - falling		1.90	2.00		V
MCU-VDC	MCU supply voltage		1.71		3.6	V
VDC-UVLO-R	VDC level to trigger DC/DC under voltage lock out (resistor)			2.025		V

1. Final product characteristics depend upon the antenna(s) used, antenna coupling and tuning, escutcheon characteristics, and external environment characteristics.
2. Continuous carrier is not a standard mode of operation and provides a stress test. It is also used in certification testing. Must be determined by the product owner for their particular design. The power consumption depends on the operation mode, the enclosure, and the connected antenna/tuning.
3. MCU specification - actual VDC value will differ. MCU-BOR3 is enabled by default if no other BOR level is set.
4. DC/DC specification - actual VDC value will differ. The OMNIKEY SE Reader Core will cease to function until VDC is restored.

5.3 Current draw

The following measurements were performed with a 50 Ω load connected to the HF interface and the standard LF antenna where applicable for polled reads. If a real antenna is connected, the OMNIKEY SE Reader Core's power consumption changes depending on the presence of a credential and its coupling to the antenna (dependent upon shapes, sizes, distances, surroundings). For that reason, please see **RF & UHF interfaces** for indicative power consumption for particular antennas. Other antennas may result in higher or lower power consumption, especially if the antenna impedance differs from 50 Ω.

Mode	Parameter	Min.	Typ.	Max.	Unit
Normal power mode Polling for HF transponders in Autonomous mode[1] No Prox polling No credential present	Average DC current at 20°C (68°F)				mA
	Peak current[2] at 20°C (68°F)				mA
Normal power mode polling for Prox credentials (HF deactivated) No credential present	Average DC current at 20°C (68°F)				mA
	Peak current[2] at 20°C (68°F)				mA
Normal power mode Polling for HF transponders and Prox credentials No credentials present	Average DC current at 20°C (68°F)				mA
	Peak current[2] at 20°C (68°F)				mA
Normal power mode Polling for HF transponders and Prox credentials with high load applied	Current consumption with steel plate or high load credential highly coupled (e.g. concentric/covering and near) to RFID antenna(s) surface[2].			See note[3]	mA
Additional current to applicable above parameters if SAM heater is active					mA
Credential detect state Average DC current at 20°C (68°F)	HF and LF detect				µA
	LF detect only				µA
	HF detect only				µA
	No HF or LF detect (use external wake-up)				µA
	Peak current at 20°C (68°F), LF & HF detect active				µA
	BLE advertising (default rate)				µA

1. Polling cycle includes ISO/IEC14443 Type A and Pico15693. Adding more protocols to the polling cycle may vary the power consumption.
2. When the carrier is turned on, the current consumption of the OMNIKEY SE Reader Core may build to create the required magnetic field. The peak currents are also considered in the average current measurement. Peak currents shown in this table are without a credential or metallic object in the working zone of the antenna, unless otherwise noted.
3. Maximum seen with HID antenna in free air (<temperature, antenna>, continuous carrier HF) is <<TBD>> mA. Maximum current must be determined by the product owner for their final particular design. The power consumption depends on the operation mode, the enclosure, and the connected antenna/tuning.

5.4 Serial port electrical characteristics (P301, P302)

5.4.1 USB

Signal	Parameter	Min.	Typ.	Max.	Unit
USB-P	Input voltage				VDC
	High-level input voltage				VDC
	Low-level input voltage				VDC
	Input leakage current				µA
USB-N	High-level output voltage Ioh = -50 µA				VDC
	High-level output voltage Ioh = -4 mA				VDC
	DC output voltage, VDC=0 V				VDC
	Low-level output voltage Iol = 4 mA				VDC
	Output current				mA
USB Data Rate					

5.4.2 UART

Signal	Parameter	Min.	Typ.	Max.	Unit
UART-RX	Input voltage				VDC
	High-level input voltage				VDC
	Low-level input voltage				VDC
	Input leakage current				µA
UART-TX	High-level output voltage Ioh = -50 µA				VDC
	High-level output voltage Ioh = -4 mA				VDC
	DC output voltage, VDC = 0 V				VDC
	Low-level output voltage Iol = 4 mA				VDC
	Output current				mA
UART-RTS	High-level output voltage				VDC
	Low-level output voltage				VDC
	Output current				mA
UART-CTS[1]	High-level input voltage				VDC
	Low-level output voltage				VDC
UART Baud Rate				230400	bps

1. Only available at P702.

5.4.3 USART

Signal	Parameter	Min.	Typ.	Max.	Unit
USART-RX	Input voltage				VDC
	High-level input voltage				VDC
	Low-level input voltage				VDC
	Input leakage current				µA
USART-TX	High-level output voltage Ioh = -50 µA				VDC
	High-level output voltage Ioh = -4 mA				VDC
	DC output voltage, VDC = 0 V				VDC
	Low-level output voltage Iol = 4 mA				VDC
	Output current				mA
USART-RTS/DE	High-level output voltage				VDC
	Low-level output voltage				VDC
	Output current				mA
USART-CK	High-level output voltage				VDC
	Low-level output voltage				VDC
	Output current				mA
USART-CTS	Not available				
USART baud rate				230400	bps

5.4.4 Tamper inputs

Signal	Parameter	Min.	Typ.	Max.	Unit
nOSDP-TAMPER-IP	Input voltage				VDC
	High-level input voltage				VDC
	Low-level input voltage				VDC
	Input leakage current				µA
nMCU-TAMPER-IP	Input voltage				VDC
	High-level input voltage				VDC
	Low-level input voltage				VDC
	Input leakage current				µA
UART-RTS/DE	High-level output voltage				VDC
	Low-level output voltage				VDC

5.4.5 GPIO & 3V3AWAKE-OP

Signal	Parameter	Min.	Typ.	Max.	Unit
GPIO1, GPIO2/ USART-CK	Input voltage				VDC
	High-level input voltage				VDC
	Low-level input voltage				VDC
	Input leakage current				µA
	High-level output voltage Ioh = -50 µA				VDC
	High-level output voltage Ioh = -4 mA				VDC
	DC output voltage, VDC = 0 V				VDC
	Low-level output voltage Iol = 4 mA				VDC
	Output current				mA
3V3AWAKE-OP	High-level output voltage				VDC
	Low level output voltage				VDC
	Output current			100	µA

5.5 Host port electrical characteristics (P701, P703)

5.5.1 UART

The UART characteristics are the same as for the serial port.

5.5.2 Inputs

The inputs' characteristics are the same as for the 30-way board-to-board connector. Applies to signals nRST-IP, nHOLD-IP, n3V3DIRECT-EN-IP.

5.5.3 Outputs

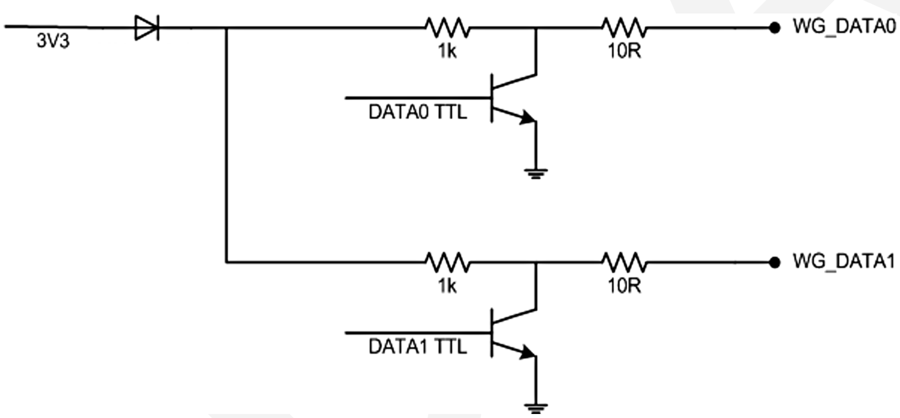
The outputs' characteristics are the same as for the 30-way board-to-board connector. Applies to signals nGLED/nCPRES-OP, NWD0-DATA-OP, nWD1-CLK-OP, nBUZZER-OP, nRLED-OP, nBLED-OP, 3V3AWAKE-OP.

5.5.4 Power

Only one pin is required for each of VDC, 3V3PERM, and GND at this connector. Characteristics are as for **5.2 Operating characteristics**.

5.5.5 Wiegand interface output circuit

The Wiegand interface output signals are backward compatible with the SE32X0B product. An internal 1 kΩ pull-up is connected via a diode to the 3V3SW supply (switched). An unswitched external pull-up to 5 V can be connected if required for level translation purposes, sized within the current rating of the outputs.



Wiegand electrical characteristics

Signal	Parameter	Min.	Typ.	Max.	Unit
nWD0-DATA-OP nWD1-CLK-OP	Current draw (into 1K + 10 ohms)		2.6		mA
nWD0-DATA-OP nWD1-CLK-OP	High level output voltage		2.6		VDC
nWD0-DATA-OP nWD1-CLK-OP	Low level output voltage			0.4	VDC

5.6 30-way port electrical characteristics (P702)

The I/O signals are backward compatible to the SE32X0B product. Some signals are present at multiple connectors. Exact specifications to be confirmed.

Signal	Parameter	Min.	Typ.	Max.	Unit
nGLED/nCPRES-OP	Current sink (open collector)			20	mA
nRLED-OP	Current sink (open collector)			20	mA
nBLED-OP	Current sink (open collector)			20	mA
nBUZZER-OP	Current sink (open collector)			50	mA
nGLED/nCPRES-OP nRLED-OP, nBLED-OP, nBUZZER-OP	Combined total allowable current sink			60	mA
nPPH-RST-OP	Current sink (open collector)			5	mA
nRST-IP	Low-level input voltage			0.3 x VDD	VDC
	High-level input voltage	0.7 x VDD			VDC
nRST-IP	nRST Schmitt trigger hysteresis			200	mV
nRST-IP	nRST MCU weak pull-up value	25	40	55	kΩ
nRST Pulse Vf(nRST)	nRST filtered pulse	70			ns
nRST Pulse Vnf(nRST)	nRST not filtered pulse 1.71 V ≤ VDD ≤ 3.6 V	350			ns
nHOLD-IP	Low-level voltage[2]			<<TBD>>	VDC
	High-level input voltage	<<TBD>>			VDC
nINT-IP	Low-level input voltage			0.8	VDC
	High-level input voltage	1.6			VDC
nEXT-WKUP-IP	Low-level input voltage			0.4	VDC
	High-level input voltage	Not applicable. Use open-collector/drain drive from connected device.			
	Pull-up to 3V3PERM	90	100	110	kΩ
I2C-SDA[1]	Low-level input voltage				VDC
	High-level input voltage			3.3	VDC
	Pull-up to +3V3 when 3V3SW is present	1.98	2.2	2.42	kΩ
	Low-level output voltage			0.4	VDC
	High-level output voltage	2.4			VDC
I2C-SCL[1]	Low-level input voltage				VDC
	High-level input voltage	<<TBD>>		3.3	VDC
	Pull-up to +3V3 when 3V3SW is active	1.98	2.2	2.42	kΩ
	Low-level output voltage			0.4	VDC
	High-level output voltage	2.4			VDC

1. Reserved for use with expansion circuitry
2. Improved Vinl threshold for nHOLD-IP input

5.7 Regulated voltage outputs

There are no regulated voltage outputs for user circuitry. 3V3PERM is supplied to the HF antenna port for use with older HF antennas only.

Signal	Parameter	Min.	Typ.[1]	Max.	Unit
+3V3PERM (normal supply)	Output voltage		3.3		VDC
+3V3PERM (3V3-Direct supply)	Output (and input) voltage		3.3		VDC

1. With Vdc within specification.

5.8 HF (13.56 MHz) carrier output

The HF interface is designed to work with a tuned HF antenna having both series and parallel tuning elements present.

Signal	Parameter	Min.	Typ.	Max.	Unit
HF-ANT	HF carrier		750	1000	mW

Note: The output power depends on the connected antenna and its impedance. For optimum performance, a 50 Ω tuned antenna is recommended.

5.9 LF (125 kHz/Prox) carrier output

The LF interface is designed to work with an antenna coil of 800 µH ±2% and 33 Ω Rdc and this limits the output peak current compared with that shown below.

Signal	Parameter	Min.	Typ.	Max.	Unit
LF-TX1, LF-TX2	Output peak current			330	mA

5.10 Start-up voltages

Signal	Parameter	Min.	Typ.	Max.	Unit
VDC	Input voltage RCx55100000 (normal supply)	3.3	3.6	6 V	VDC
	Input voltage RCx55100000 (3V3-Direct supply)	3.1	3.3	3.6 V	VDC
	VDC rise rate to ensure internal power-on reset signal of credential detect microcontroller				V/ms

The best way to control the OMNIKEY SE Reader Core at start-up is to actively control the reset line (nRST-IP). If the reset line is held low until the power supply has stabilized, the unit will start when the reset line is released, with full functionality and meeting all the specifications.

If you do not control the reset line, the OMNIKEY SE Reader Core will become active once the rising edge brown-out reset threshold has been exceeded, but cannot be guaranteed to meet specifications until the voltage reaches the minimum specified in **5.2 Operating characteristics**. Note also that the RF power will be reduced when the input voltage is below or at the minimum compared with the typical voltage value.

Note: The above also applies in the reverse situation, when power declines.

5.11 Host power supply levels, indications and management

As each embedded system design is different, the end product owner/system architect is responsible for maintaining and supervising adequate power to the OMNIKEY SE Reader Core.

To ensure satisfactory operation of the OMNIKEY SE Reader Core, the power supply from the host system or external supply must remain within the specified operating limits. Failure to observe these limits may result in reduced performance, reliability, lifetime, or malfunction, none of which may be obvious at the time. If the absolute maximum ratings can be exceeded, then additional external protection for the OMNIKEY SE Reader Core or control of the supply voltage must be provided.

The OMNIKEY SE Reader Core includes the following functions related to the external supply Vdc.

- MCU Brown out reset - see **5.2 Operating characteristics**.
  - MCU BOR3 is chosen to best protect the OMNIKEY SE Reader Core against supply drops whilst maintaining performance. MCU BOR3 is significantly above the minimum operating voltage of the MCU.
  - The BOR incorporates hysteresis.
- DC/DC regulator UVLO (under voltage lock-out) - see **5.2 Operating characteristics**.
  - The UVLO threshold is above the minimum operating voltage of the MCU.
  - The UVLO incorporates hysteresis.
- DC/DC regulator enters "100% pass-through" mode when Vdc is insufficient for regulation to 3.3 V.
- Discrete flash IC to buffer firmware updates and protect against interruptions.

5.11.1 Operation lifecycle with a declining external power supply

Ideally the product design should ensure the OMNIKEY SE Reader Core is held in reset, or its power is removed whenever VDC is outside its specification. Alternatively, place the OMNIKEY SE Reader Core into SHUTDOWN mode to minimize power consumption. In the event that this is not done, the following sequence can occur.

- Start: normal operation, often in credential detect or credential polling state.
- As VDC declines, the current consumption increases.
- Later: VDC minimum voltage no longer supplied due to battery decline.
- Detection/polling/reading performance reduces.
- MCU BOR falling edge trigger activates. OMNIKEY SE Reader Core ceases activity and consumes minimal power. 3V3AWAKE-OP is low.
- Battery recovers due to decreased load and/or temperature change.
- MCU BOR may de-activate if the rising edge trigger threshold is exceeded and the OMNIKEY SE Reader Core attempts to resume operation.
- Repeat above sequence.
- Eventually the battery cannot recover enough to re-start the OMNIKEY SE Reader Core and declines very slowly unless other current sinks are present.
- UVLO is triggered (normal power scheme only).
- 3V3PERM is unpowered (normal power scheme only) and all OMNIKEY SE Reader Core circuits including pull-ups become unpowered.
- The battery declines even more slowly as semiconductor thresholds are reached.
- Finish: battery beyond use.

5.11.2 Indicators of insufficient supply

Normal supply scheme

- 3V3PERM voltage sustained decrease or declining from 3V3 (but above 2.5 V).
  Indicates that VDC is insufficient for normal regulation by the DC/DC regulator. In normal supply mode, 3V3-Direct-IP is at the same voltage as the 3V3PERM power domain (but must not be used to power external circuitry). It would be possible to monitor 3V3DIRECT-IP and trigger an external action based on a buffered voltage level. 3V3PERM does not provide any indication of a BOR event but would go low if the DC/DC UVLO triggered. Monitoring the average VDC current may be useful if VDC is normally nearer 5 V or 6 V and credential detect is not used.
- 3V3PERM steady at, or declining from, 1.9 V.
  This indicates that the DC/DC UVLO circuit has triggered.
- 3V3AWAKE-OP deactivation in credential polling state.
  3V3AWAKE-OP will deactivate after the MCU BOR3 is triggered until Vdc rises sufficiently.

  > **Note:** Even though BOR3 has hysteresis, if the supply recovers sufficiently to reactivate the OMNIKEY SE Reader Core but not enough to sustain higher currents such as credential reading, then multiple BOR events may occur.

  3V3AWAKE-OP is not active in the credential detection state and cannot be used to check the Vdc status until a credential detect or other wake-up event occurs.
- In SHUTDOWN mode.
  The only in-built protection mechanism that triggers (for low VDC) is the UVLO. The MCU BOR circuit is inactive. 3V3PERM will become unpowered (including all pull-ups) when the UVLO triggers.

3V3-Direct supply scheme

- In 3V3-Direct mode it is likely that other product functions will also be affected by an insufficient 3V3 supply, so supply monitoring and control external to the OMNIKEY SE Reader Core is recommended.
- 3V3PERM will decline in line with 3V3DIRECT-IP/VDC. The 3V3PERM supply is not affected by the UVLO or BOR mechanisms.
- 3V3AWAKE-OP will behave as in the normal supply mode.

5.11.3 Effect of BOR or UVLO events

If a BOR or UVLO event occurs, the OMNIKEY SE Reader Core will become unresponsive until sufficient power is restored. The host will not be proactively alerted (by any message) that a BOR or UVLO event is about to occur or has occurred. However, the 3V3AWAKE-OP signal will go low, and this could be used to alert the host system (except in systems using credential detect where 3V3AWAKE-OP is normally low). The host system designer has a choice: accept the OMNIKEY SE Reader Core shutting down due to insufficient power or take active measures to monitor, predict and control power levels.

Indications of a BOR activation are:

- MCU is in reset.
- OMNIKEY SE Reader Core no longer issues the (configurable) 'Alive' message.
- The OSDP regular polling event goes unanswered.
- No serial communications.
- LED(s) extinguishes (dependent upon configuration of the LED behaviors).
- 3V3AWAKE-OP Low (for credential polling state operation).

5.11.4 Suspending OMNIKEY SE Reader Core operation

For systems where a battery is used to power the OMNIKEY SE Reader Core, for example in a back-up battery supply scenario or a portable device, the host system may wish to ensure that operation of the OMNIKEY SE Reader Core or power to the OMNIKEY SE Reader Core is suspended before the battery supply capability (voltage, current) is insufficient for requirements. For the OMNIKEY SE Reader Core, suspension of operation is caused by asserting and maintaining nRST-IP low, or setting it in Shutdown mode, or by removing power from the OMNIKEY SE Reader Core. The nHOLD-IP signal cannot be used to suspend operation for the purposes of OMNIKEY SE Reader Core protection.

Care is needed in setting up the management of such a system. For example, an unloaded battery may have a voltage of 6 V but be incapable of supplying the current needed for higher power consumption operation of the OMNIKEY SE Reader Core (such as reading credential data) without its voltage dropping below the recommended operating limits for the OMNIKEY SE Reader Core. Profiling the battery voltage/current delivery capacity curve over the lifespan of the battery or the multi-battery system across the product operating range (for example, temperature, humidity and battery type) is recommended. When the OMNIKEY SE Reader Core exits the credential detect state into the credential polling state and then credential reading, current consumption jumps by a factor of 10,000 or more.

In an embedded device, the credential detect state is not a suspension of operation of the device.

Hysteresis in the suspension system is desirable to avoid a loop of reset, power-up, reset, power-up.

The host system designer should determine a suitable voltage limit, or other method, at which to effect suspension and a method of doing so. It may be that the overall embedded system already has provision for operation in a battery powered situation.

One possible method is to use an independent reset IC which operates its reset output once its supply voltage lower limit is reached. Such ICs are plentiful and inexpensive. The host system designer should decide when and how to allow exit from the suspension of operation state of the OMNIKEY SE Reader Core. This may be when the power supply is deemed adequate for use once more, or may require a replacement of the battery, for example.

5.11.5 Using batteries

Alkaline, lithium, rechargeable, and lead acid batteries will have different profiles. Battery replacement management is not straightforward to implement and will depend upon the particular needs of each individual product. An indication that replacement of the battery is necessary may be conservatively based upon:

- A simple timespan.
- A measurement of the loaded/unloaded battery voltage in an alkaline system.
- An event counting method, whereby the operations of the device are counted and limited to a safe number obtained by system testing during the product design. This method is particularly suited to lithium battery supplies, where the output voltage of the battery does not steadily decline from first use to the exhausted state.

Cold temperatures can reduce battery performance. Some batteries are not specified for low temperatures.

If the host system can be battery powered and does not already include a suitable power management method, it is recommended that it adopts one to ensure its own operation is predictable. The host system may choose to include a system-wide or a partial reset scheme as appropriate. The reset scheme should cover the product operating temperature range or wider and incorporate hysteresis. Take care that any supervision IC is rated for the required supply voltage of operation.

If the OMNIKEY SE Reader Core is being operated in credential detect mode, then the quiescent current (Iccq) of any supervisory IC becomes important. Devices vary greatly in their Iccq specification, from as little as 150 nA to 30 µA or more for other devices.

> **Note:** Some reset devices operate only to 3.6 V or 6 V supply voltage.

5.11.6 Which voltage to monitor?

Which voltage (if any) is monitored will affect the operating voltage specification of any reset supervisor IC and this can influence the Iccq of that IC. With the OMNIKEY SE Reader Core, there is a choice of voltages which could be monitored.

- The VDC voltage (main power supply to the OMNIKEY SE Reader Core). The specification for VDC is given in **Electrical specifications**, but the host system will have its own specification for the OMNIKEY SE Reader Core power supply voltage. If this voltage is used, any voltage drops through the input circuitry and voltage regulator of the OMNIKEY SE Reader Core will not be taken into account. Monitoring this voltage might be more suitable if the same supply feeds other devices in the embedded system that also need supervision.
- The 3V3DIRECT-IN port of the OMNIKEY SE Reader Core. This is present both on the 30-way connector and also on the antenna connector and/or antenna connection solder holes. This point closely reflects the voltage supplied to the microcontroller on the OMNIKEY SE Reader Core. This signal has the advantage of being regulated to a nominal 3.3 V so that any supervisory IC can potentially have a lower operating voltage rating than one used on the VDC voltage point.
- Only monitor the 3V3AWAKE-OP output of the OMNIKEY SE Reader Core if it is in a permanent awake state. This is switched off in credential detect state until a card is detected.

Note that either voltage supply may experience a transient dip when the OMNIKEY SE Reader Core wakes from credential detect state and the credential reading system boots up and looks for a card. The OMNIKEY SE Reader Core has improved power domain circuitry compared to the iCLASS SE Reader Module. The supply glitch duration needed to trigger the supervisor should be specified in its datasheet; there are many devices available with an allowable glitch of 1 ms or more.

The product owner has the responsibility to test their product and also ensure that the OMNIKEY SE Reader Core is operated within its specifications. Performance may have declined before the nRST-IP assertion voltage is reached.

5.12 Behavior with external power supply variations

If the input power supply to the OMNIKEY SE Reader Core declines below the recommended operating limits, the antenna signal voltages will decline and card reading performance may degrade until the brown-out reset falling edge threshold is passed and the OMNIKEY SE Reader Core then ceases all activity. The best credential reading capability is exhibited when the supply voltage is at the typical recommended voltage or higher. Note that an external battery voltage may have declined due to cold temperatures, increasing the possibility of a BOR event.

OMNIKEY SE Reader Core operation will resume when the BOR rising edge threshold is exceeded at the MCU.

The external power supply should maintain good output load tolerance and transient performance to avoid triggering the BOR feature and to maintain credential detection reliability. It should ideally be a linear regulator system to avoid the switching noise generated by switched mode power supplies. If a switched mode supply is used, then it is recommended that it switches at 1 MHz or greater. Switching frequencies below this, particularly in the 25 kHz to 800 kHz region, may result in radiated interference which impairs the credential data read processes.

Regardless, the OMNIKEY SE Reader Core should always be operated within its recommended limits and power be supervised for the overall product. See **5.2 Operating characteristics**. Excessive VDC noise may result in false wake-ups of the OMNIKEY SE Reader Core when in credential detection.

Section 06

RF & UHF interfaces

6.1 Introduction

Depending on the configuration, the OMNIKEY SE Reader Core offers up to three different credential interfaces:

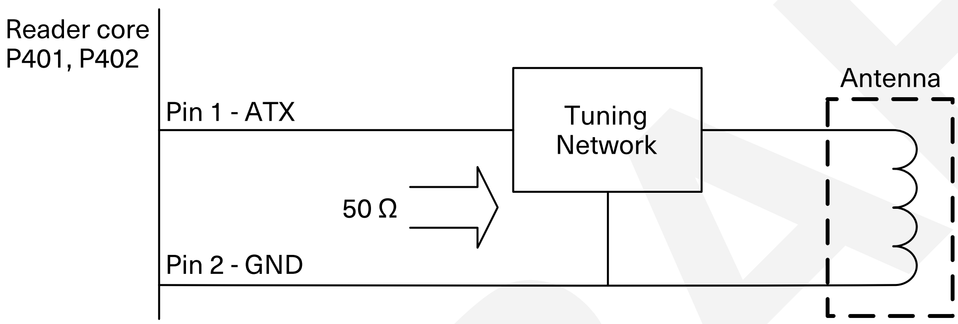
- HF interface for 13.56 MHz transponders.
- Prox (LF) interface for 125 kHz transponders.
- BLE interface for HID Mobile Access and device management.

6.2 HF interface (13.56 MHz)

The HF interface is optimized for operation with 50 Ω tuned antennas. The HF interface does *not* have an output impedance of 50 Ω.

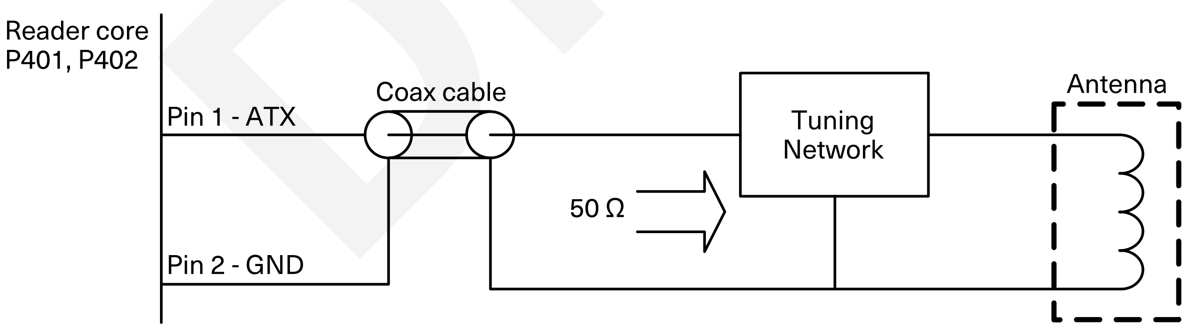
Do not invoke HF RFID operations without an HF antenna fitted, as doing so can result in significant current consumption.

6.2.1 Operation with 50 Ω tuned antennas



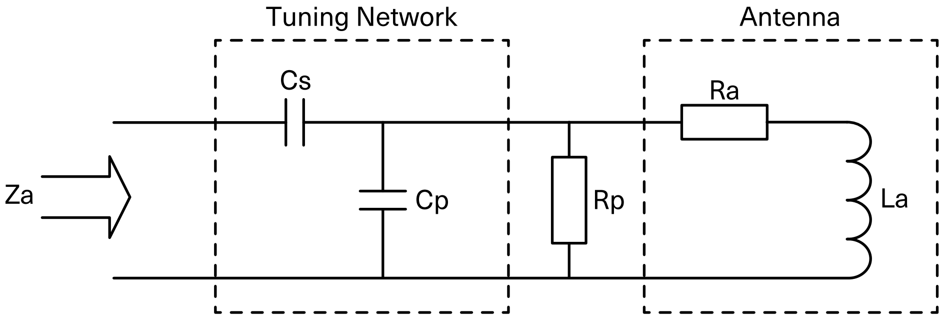
The impedance of 50 Ω allows for integrated antennas, as well as remote antennas connected through a coax cable. Use a coaxial connection whenever operating the OMNIKEY SE Reader Core in Autonomous mode without credential detection, if possible.

6.2.2 Remote antenna connection



Create a simple tuning network by using two capacitors, one serial and one parallel.

Tuning network - two capacitors



Za = antenna impedance
Cs = serial capacitor
Cp = parallel capacitor

Rp = parallel damping resistor for Q-factor control
Ra = serial antenna resistance
La = antenna inductance

For the capacitors, C0G or NP0 dielectrics with a voltage rating of 50 VDC or larger are recommended. In practice, Cs and Cp may consist of several parallel capacitors to get better accuracy.

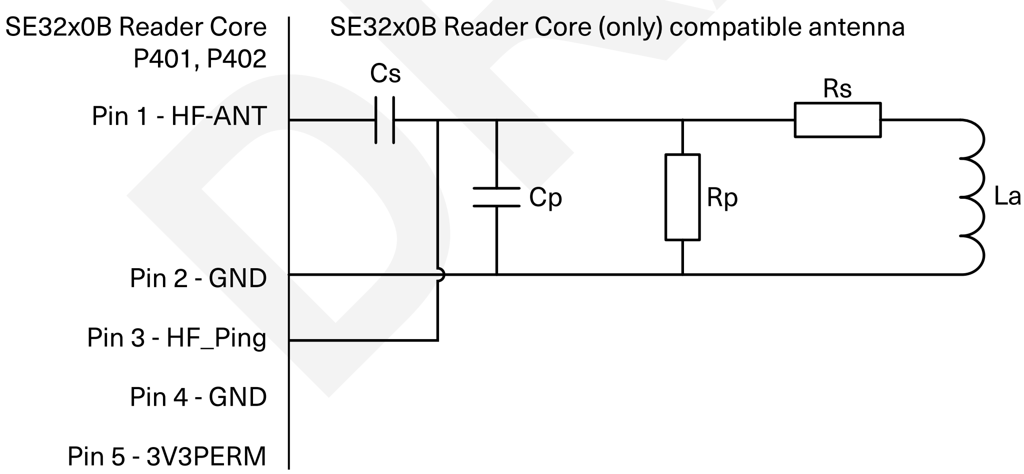
Be aware that HID offers further documents, support, and services in terms of antenna design and support. These might require special or service level agreements. Contact your sales manager for details about this offering.

6.2.3 Credential detect antenna connections

The OMNIKEY SE Reader Core HF antenna interface for credential detect operation is shown below. This interface is also fully compatible with HF antennas used with the SE32X0A and SE32X0B iCLASS SE Reader Modules.

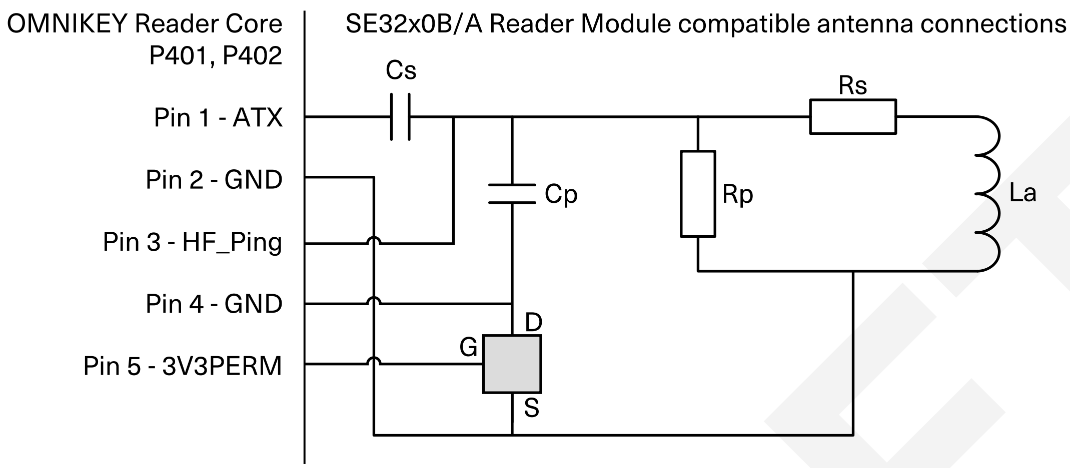
> **Note:** Pins 4 and 5 of the interface are included for backward compatibility with SE32X0A compatible antennas.

Connection to a new OMNIKEY SE Reader Core/SE32X0B (only) compatible antenna



Connection to an SE32X0B and SE32X0A compatible antenna

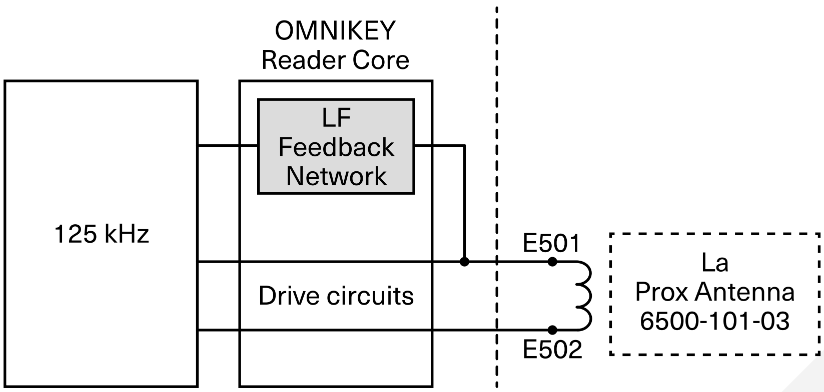
To allow for credential detection, for the SE32X0A iCLASS SE Reader Module it was necessary to take additional measures at the antenna circuit. A transistor and two additional connections were introduced to enable the low power card detection of the iCLASS SE Reader Module SE32x0A.



> **Note:** The OMNIKEY SE Reader Core is capable of detecting both HF and LF (Prox) credentials/transponders in the credential detect state and has a dedicated detect circuit for each type. If both credential types will be used, then consider using the combined HF/LF antenna. Correct positioning of the antenna in all three dimensions, and its distance from any metallic features, is critical for viable and correct tuning and performance. If a BLE antenna is also being used, try to keep it distant from the HF antenna, as the HF antenna will affect the BLE antenna.

6.3 LF/Prox interface (125 kHz)

The LF interface is optimized for connection to the HID Prox antenna (6500-101-03) or HF/LF antenna (4090A16). If this antenna or one with equal electrical characteristics is used, no additional components are required. LF credential detection is available.



If the antenna has a different electrical characteristic than the HID 6500-101-03 Prox antenna, external components may be necessary to adjust the resonant frequency and quality factor to the desired values.

The desired quality factor of the system is between 5 and 15 depending on antenna size.

> **Note:** ECR format PSK modulation proximity credentials are not currently supported by the OMNIKEY SE Reader Core.

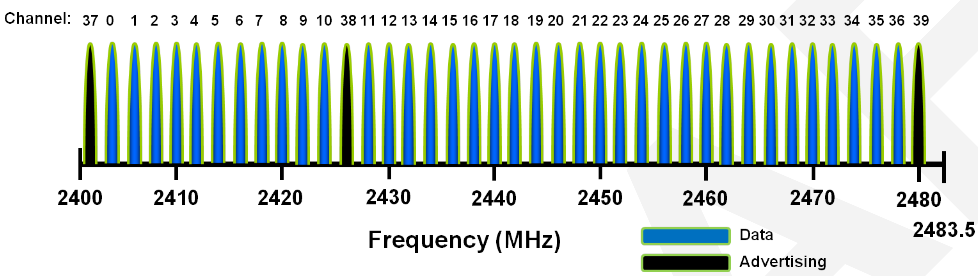
HID Global provides additional documents, support, and services for antenna design and support. These documents may require service level agreements. Contact your sales representative for more details.

6.4 Bluetooth Low Energy interface

6.4.1 Overview

The OMNIKEY SE Reader Core implements a Bluetooth Low Energy 5.0 interface. Different from the HF and Prox systems, the Bluetooth Low Energy interface is a traditional radio communication interface intended to operate mainly in the far field region. Bluetooth Low Energy uses electromagnetic waves for communication and does not rely on the magnetic field in the near field region. For this reason, this document also shows the traditional antenna parameters like directivity, antenna efficiency, and radiation pattern in **7.8 Bluetooth Low Energy interface (2.44 GHz)**.

Bluetooth Low Energy operates in the ISM Bluetooth frequency range (2400 MHz to 2483.5 MHz) and exists as 40 discrete channels, three of which are reserved as advertising channels, with the other 37 being data channels, as shown below. A channel-hopping scheme is used. Channels 37, 38, and 39 are the advertising channels, distributed within the frequency range as shown below. Advertising channels are used for device discovery, connection establishment, and broadcast transmissions. Data channels are used for bidirectional communications and adaptive frequency hopping. The OMNIKEY SE Reader Core allows for different rates of BLE advertising to be configured, to tailor the power consumption to the application.



Note that the channel number of the lowest frequency channel is 37, and it is an advertising channel. The center frequency at which channel 37 transmits is 2402 MHz, not 2400 MHz. This means that emissions from channel 37 should not exist below 2400 MHz to any material extent. Similarly, channel 39 is centered at 2480 MHz, not 2483.5 MHz. These distinctions are important if compliance testing is being conducted. Channel spacing is 2 MHz. The channel center frequency tolerance specification is 75 kHz. There is also a deliberate additional frequency drift within a data packet of up to ±40 kHz (with a maximum drift rate of up to 400 Hz/µs allowed anywhere within a packet) which is built into the Bluetooth specification. The latest version is available on the **Bluetooth® Technology Website**.

Transmission power can be adjusted by configuring the OMNIKEY SE Reader Core, as can the level of RSSI (Received Signal Strength Indication) needed to permit communications. This is important when multiple devices exist in Bluetooth range of each other.

6.4.2 Impact of reader environment on the Bluetooth Low Energy interface

From an integration point of view, similar rules as for the Prox and HF interface apply.

Generally, materials and especially conductive materials placed very close to the BLE antenna and drive circuit (<20 mm) will have a direct impact and will load the antenna and affect the efficiency and radiation pattern. Due to the high frequency of 2.44 GHz, even plastic materials will lead to changes in the resonant frequency as well as slight changes in the radiation pattern.

Materials placed further away (outside the reactive near field of ~20 mm) will not directly load the antenna. However, as electromagnetic waves are used for communication, even obstacles at several meter distance may have an impact on the performance due to reflection/diffraction etc. For the direct integration of the reader, it is important to consider that conductive planes within the housing may lead to reflections of the magnetic wave and change the radiation pattern of the overall device. Therefore, testing must be with the antenna in-situ in a representative build of the final product.

As also mentioned in the above section other readers or other sources of RF field can also affect the performance and characteristics. An example of this would be an environment with high level Wi-Fi or many 2.4 GHz radios, for example Bluetooth headsets, Zigbee networks, or microwave transmitters.

Note that the HF antenna of the OMNIKEY SE Reader Core will affect the Bluetooth Low Energy antenna performance, as well as the OMNIKEY SE Reader Core itself.

Section 07

Antennas

7.1 Introduction

All antennas offered for the OMNIKEY SE Reader Core are optimized for a free-air environment. A free-air environment is one in which there are no external effects on the field produced by the antenna which might degrade its performance, such as metal or stray capacitance.

When an air-tuned antenna is placed near metal, its tuning is affected. This causes a degradation of read performance. Metal includes printed circuit boards, especially those with substantial ground and/or power planes.

The HID air-tuned compatible antennas are optimized for a 50 mm (1.97") interconnect cable length. Different cable lengths may also lead to performance degradation and optimization may be required.

Environmental deviations away from free air, as well as antenna interconnect cable length and routing the HF antenna interconnect cable along metal, require antenna optimization to ensure that the RF interface operates optimally within the integrated environment. It is suggested that the antenna and its interconnect cable are integrated into the end product to mirror a free-air environment. Routing of the antenna connections should be repeatable and consistent. Positioning of the antenna and of related items should be repeatable and consistent.

If an identical OMNIKEY SE Reader Core/antenna arrangement is used in two different products, and those products have different metallic content or positioning (relative to metal) then those products will perform differently.

Do not invoke HF RFID operations without an HF antenna fitted, as doing so can result in significant current consumption.

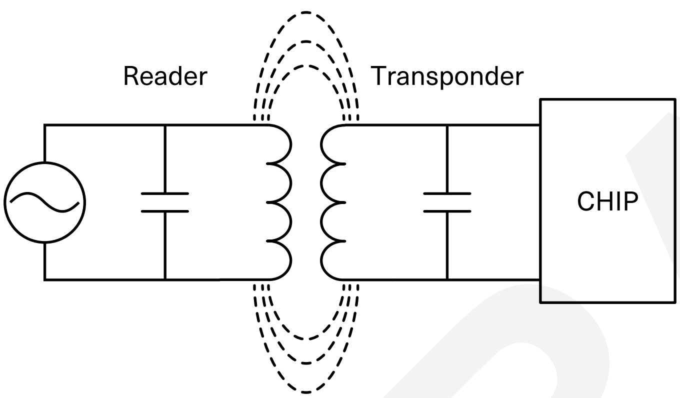
7.2 Basic antenna operation

Credentials obtain their power from the magnetic field generated at the antenna of the reader. At the operating frequency of the reader, this interaction is similar to the operation of an air-core transformer. When an antenna is energized by an alternating current, the induced magnetic field is directly proportional to the area enclosed by the antenna loop. The larger the loop, the more excitation current is required to produce the same level of magnetic flux. That flux covers a larger area and so the read range is extended. Other external factors affect the magnitude of this induced magnetic field. Magnetic lines of flux generated by a loop antenna are oriented perpendicular to the plane of the loop. This is known as the right-hand rule: the magnetic field wraps around the wire in the direction of current flow.

7.2.1 Inductive coupling

An inductively coupled transponder (e.g. credential) usually consists of a single chip and an attached coil which is used as an antenna. Most inductively coupled transponders are passive, meaning that power is supplied by the reader's magnetic field.

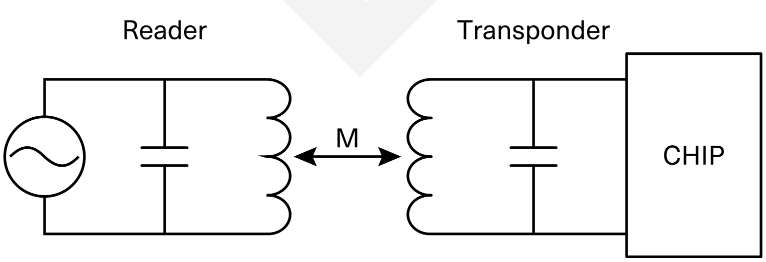
Inductive coupled transponder



Mathematically, treat the coupling as a simple alternating magnetic field. The wavelength at the frequencies of interest, 22.1 m (72.5 ft) at 13.56 MHz, is much greater than the distance between the tag and reader. Both antenna coils (transponder and reader) have a parallel capacitor, creating a parallel resonant circuit. The capacitor is chosen to achieve a resonance frequency near the working/carrier frequency of 13.56 MHz.

Mutual inductance between reader and transponder antenna

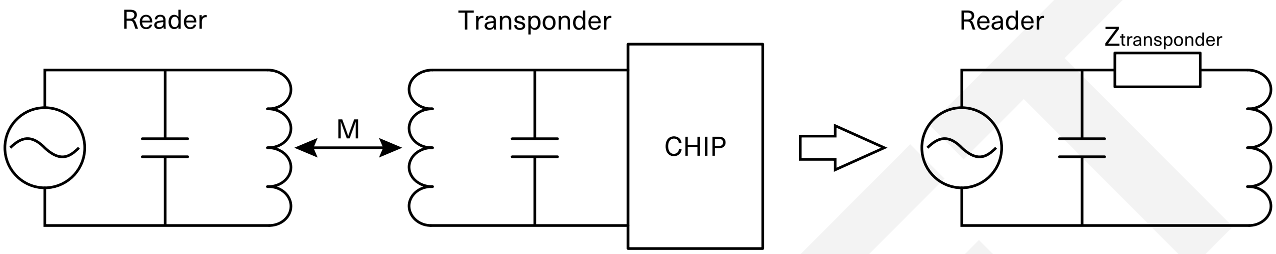
Interpret the arrangement of the two coils as a loosely coupled transformer with a coupling factor that varies with position and geometry.



7.2.2 Load modulation

As previously mentioned, interpret the inductively coupled system as a transformer. Putting a transponder (with an SRF around 13.56 MHz) into the magnetic field of a reader absorbs energy from the field. This loading of the reader's antenna, caused by the transponder, is represented as transformed impedance at the antenna.

To communicate with the reader, the transponder switches an additional load resistor across its own antenna. This results in a further impedance/voltage change at the reader's antenna. Therefore, the credential does not actually transmit.



7.3 Antenna integration

Magnetic field antennas operate optimally within a free-air environment because the magnetic field propagates perpendicularly with equal magnitude to the back and front of the antenna. Antenna performance degradation due to eddy current loss begins at the point where a metallic plate begins to enter the periphery of the magnetic flux lines of the magnetic field.

Note: Magnetic field losses due to eddy currents are not recoverable.

Magnetic field loss is extremely important. As loss increases, the available magnetic field to power a credential and for the credential to load modulate is reduced, thus affecting RF performance of the system.

7.3.1 Steps to integration

Due to antenna parasitic shift and eddy current losses, RF implementation should be fully planned prior to an industrial/mechanical design. This requires experimentation (and simulation where available) to be completed, including:

- The proximity of metal obstructions, including the escutcheon.
- The presence of other items, such as circuit boards and cables, in the proximity of the antenna (including the LF antenna for HF and LF applications).
- The separation and/or overlap of HF and LF antennas in X, Y, and Z dimensions in dual-frequency applications.

Notes:
The presence of an HF antenna near a BLE antenna can affect the performance of the BLE antenna.
Consistent, repeatable positioning of all items is essential for a high yielding product.

7.3.2 Antenna interconnect cable

The antenna interconnect cable is also designed to be routed in a free-air environment. Routing the antenna interconnect cable across metal structures shifts the antenna characteristics and requires optimization. The routing of the antenna interconnect cable should be consistent.

7.3.3 Training and assistance

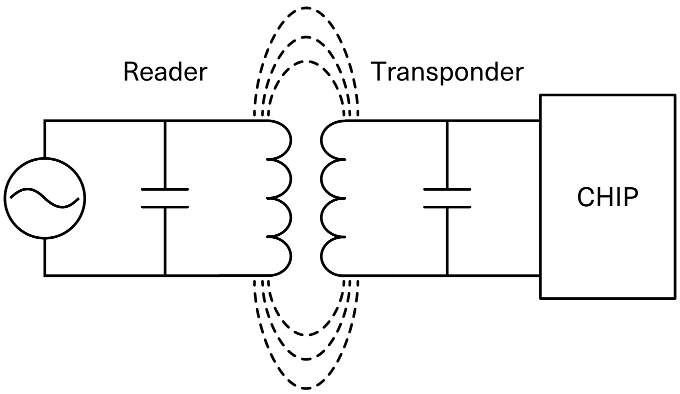
HID Global Embedded Systems field applications engineering staff will provide RF integration review and conceptual training for integrators. In addition, HID provides antenna optimization and design services through a customer product opportunity program.

7.3.4 Inductive coupling

The HF and Prox interfaces are both inductive coupling systems. An inductively coupled transponder usually consists of a single chip and an attached coil, which is used as an antenna.

Most inductively coupled transponders are passive, meaning that the reader supplies power. To achieve this, the reader produces a magnetic field that the transponder uses for power.

Inductive coupling system



Mathematically, the coupling can be treated as a simple alternating magnetic field. The wavelength at the frequencies of interest is much higher than the distance between the tag and reader (22.1 m at 13.56 MHz) so the antennas operate in the near field region (not like traditional antennas operating in the far field). Both antenna coils (transponder and reader) have a parallel capacitor, creating a parallel resonant circuit. The capacitor is chosen to achieve a resonance frequency near the working/carrier frequency of 13.56 MHz or 125 kHz.

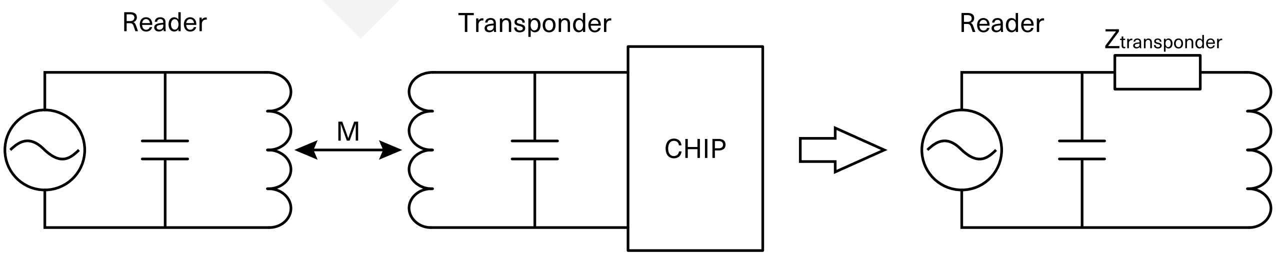
Essentially the two coils form a loosely coupled transformer, with a coupling factor that varies with position and geometry.

7.3.5 Load modulation

As previously mentioned, the inductively coupled system can be interpreted as a transformer. Putting a transponder (with an SRF around 13.56 MHz / 125 kHz) into the magnetic field of a reader absorbs energy from the field. This loading of the reader's antenna, caused by the transponder, can be represented as a transformed impedance at the antenna.

To communicate with the reader, the transponder switches an additional load resistor across its own antenna, which results in a further impedance/voltage change at the reader's antenna.

Load modulation principle



7.3.6 Impact of reader environment on performance

Inductive coupling systems are especially affected by conductive materials in their proximity. The alternating magnetic field (13.56 MHz or 125 kHz) will induce voltage in any nearby conductor. If a loop within that conductor exists (e.g. metal plate) current flows and energy is dissipated. This effect is referred to as eddy current losses. Those eddy currents typically flow within a certain surface thickness given by the skin depth.

$$\delta = \sqrt{\frac{\rho}{\pi \cdot f \cdot \mu_0 \cdot \mu_r}}$$

δ = skin depth
ρ = electrical conductivity
f = frequency
μ_0 = permeability in free space ($4\pi \times 10^{-7}$ H/m)

The following table provides an overview on typical skin depths for certain materials:

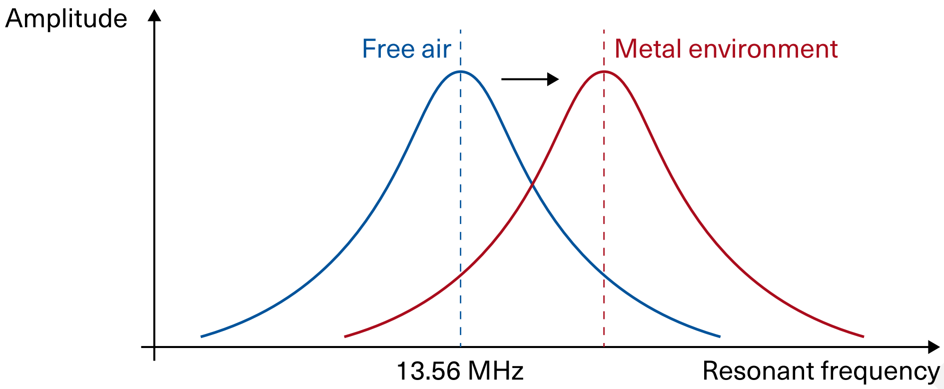
Material	δ at 125 kHz (µm)	δ at 13.56 MHz (µm)
Aluminum	238	23
Copper	186	18
Carbon film	8422	809
Tap water	8000	2000
Animal tissue	2000	600

The table above demonstrates that the Prox interface (125 kHz) is less affected by conductive materials than the HF interface (13.56 MHz) due to the larger skin depth. Given this, Prox antenna locations against highly conductive metal surfaces should be masked by a low conductivity metal such as zinc or another compound called FINMET. Even a fraction of a wavelength thickness of zinc will greatly reduce eddy current losses at 125 kHz (0.5 mm thickness).

However, eddy current losses are only one effect that can be observed. In addition to the power dissipation in nearby conductive material, there is also a detuning effect. The presence of metal or other conductors will lead to a change of the effective antenna inductance. The amount of change depends on the geometrical arrangement.

This change in inductance leads to a shift in the antenna's resonance frequency, which accounts for most performance losses due to metal environments.

Detuning effect on an HF antenna



Due to the upwards shift in the antenna resonance frequency, the magnitude of the magnetic field may be reduced significantly. This will also impact the current consumption of the reader.

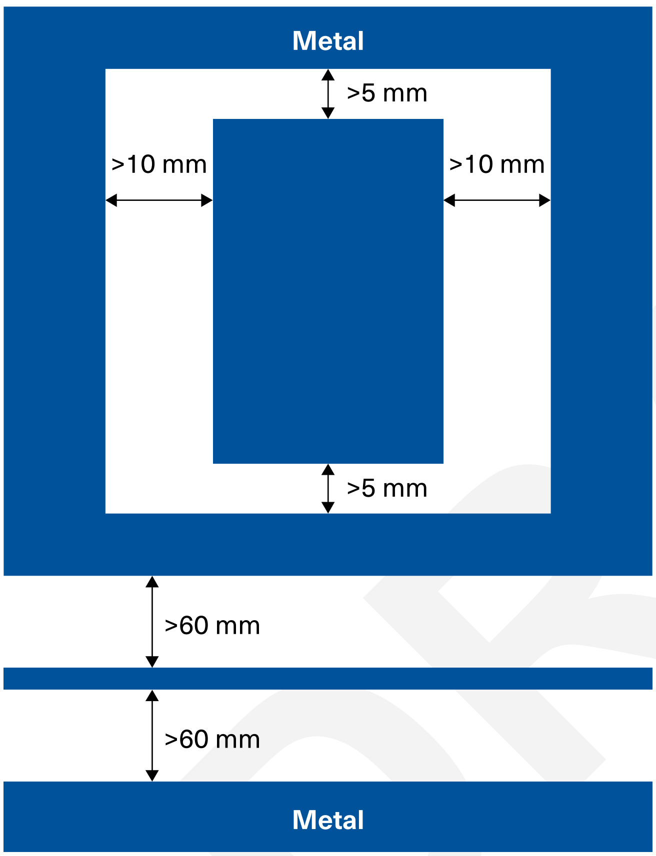
> **Note:** A Prox or HF antenna must not have its free-air frequency exactly at the carrier frequency (13.56 MHz or 125 kHz) but may intentionally be tuned with a slight offset for better sensitivity. Still the detuning effect of metal or other conductive materials will impact on the overall performance.

7.3.7 Mitigation of environmental effects

The best way to avoid environmental effects on the HF and Prox interfaces is an integration that does not have conductive materials close to the board (distances >60 mm). However, in some cases this may not be achievable. If so, the coupling of the conductive planes should be reduced as much as possible. Metal that overlaps with the area of the antenna has a larger impact than metal to the side of the reader, due to the way the magnetic field wraps around the reader.

The following diagram indicates some recommendations on conductive material distances to allow the propagation of magnetic flux without induction into the metal in the surrounding area.

Recommended minimum distances of conductive materials



In case those minimum distances cannot be achieved, it should be verified whether the impact on performance is acceptable for the intended application. If this is not the case, additional measures can be taken with ferrite shields.

Ferrites are magnetically soft ceramic materials which consist of mixed crystals, or compounds, of ferric oxide and another bivalent metal oxide. The main characteristic of ferrites is that they are poor electrical conductors while having a high magnetic permeability.

This allows ferrites to be used to "steer away" the reader's field from nearby metal.

It should be noted that ferrites also change the effective antenna inductance. However, they increase other conductive planes. This means that whilst metal will shift the resonance frequency of a reader upwards a ferrite will lower it. Due to this property, carefully placed ferrite sheets inside the integration environment can largely compensate for the detuning caused by conductors.

7.3.8 Multiple readers in close proximity

If multiple readers are placed in close proximity their magnetic fields will interfere. This may lead to:

- Read performance issues due to noise in the detector.
- Ghost readings; the Prox interface is more sensitive to this than HF.

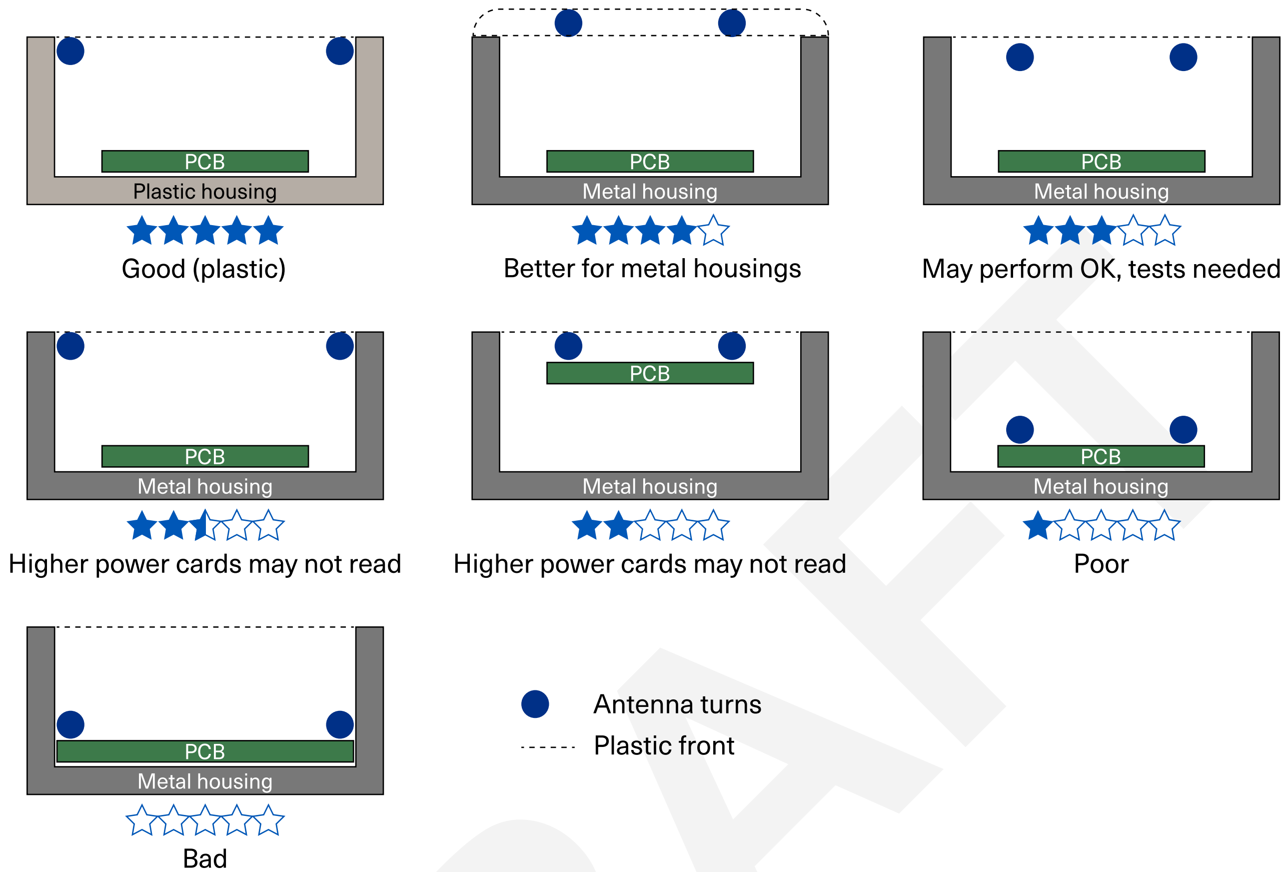
Typically, the only way to avoid such interference is to increase distance between the readers. In the case of the OK5127CK-Mini, it is recommended to have at least 50 mm distance between adjacent readers.

> **Note:** Operating only a single reader at a time will not solve the issue at smaller distances, as the deactivated reader's antenna will still act as a resonator at the frequency of interest and dissipate significant power in the field.

Some factors affecting RFID performance:

- Credential power consumption in required mode.
- Credential antenna to reader antenna coupling (relative antenna sizes, positioning, and enclosure/environment).
- De/re-tuning of the reader antenna by credential presence.
- SRF (Self Resonant Frequency) and Q factor of the credential (power delivery from reader).
- Credential LMA (answer strength to reader receiver).
- Field strength from the reader.
- Reader receive circuit discrimination/sensitivity.
- Losses into enclosure or circuit board metal.
- Detection range.

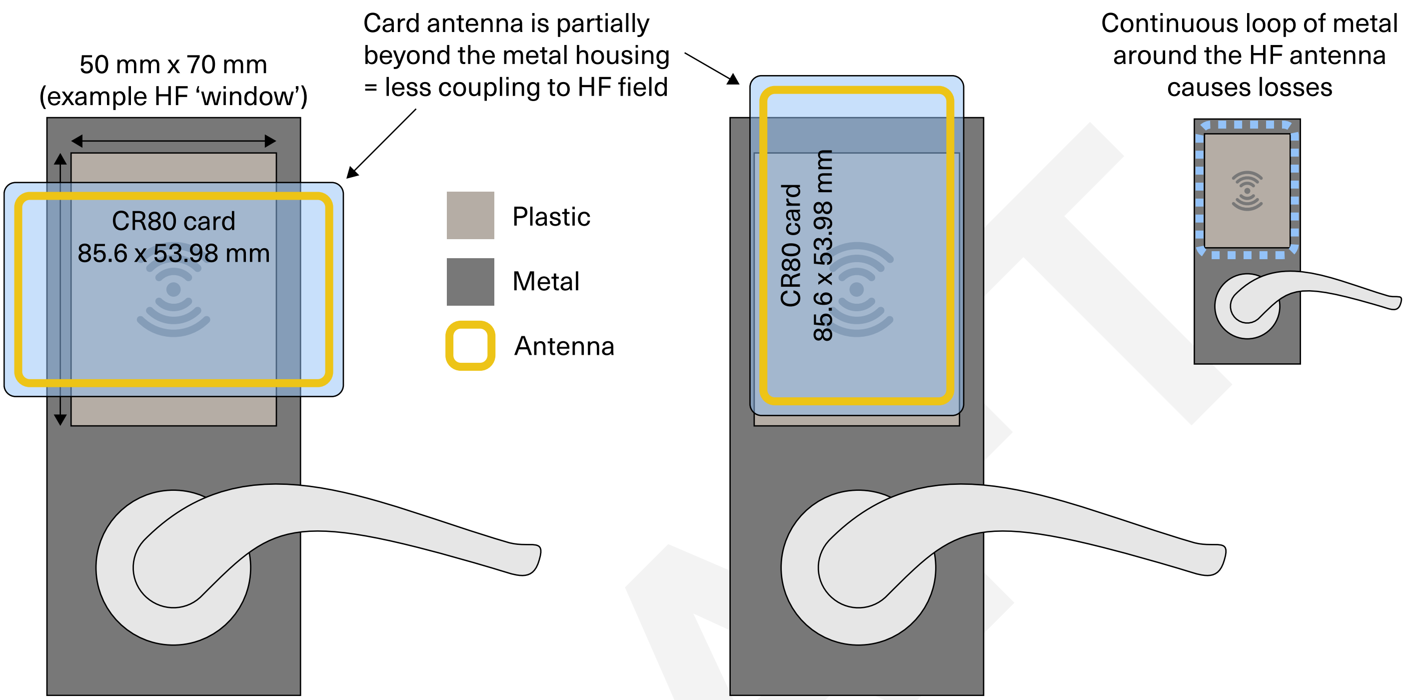
Effect of antenna to housing placement



All scenarios are dimension/separation/layout dependent. Keypads can significantly reduce freedom of antenna placement. Every scenario has different tuning components. The plastic housing performance can be affected by a metal background.

Effect of metal enclosure form factor

The metal housing of the door handle acts like a barrier to, and absorber of, the HF field, especially with the card on the lock surface.



7.4 4090A10 HF antenna (small antenna)

The 4090A10 HF antenna has a nominal impedance of ~50 Ω and optimized for operation with a 50 mm (1.97") ribbon cable. The antenna is tuned for a free-air environment.

7.4.1 Mechanical data

Detailed drawings are available at the OMNIKEY SE Reader Core website.

7.4.2 Typical read ranges

Detect and/or read ranges vary with many factors such as reader antenna power, shape, size, enclosure type, enclosure material, mounting method, and card presentation method. Credential and NFC antennas vary in shape, size, and position and may be asymmetrical within a card or device.

7.4.3 Read ranges with standard credentials

The following read ranges are for indication only. For these read range tests, the transponder serial number was read. No cryptographic operations were performed.

Card type	Manufacturer	Standard/modulation scheme	Format	Typical read range (mm)
iCLASS SR 2k/2	HID Global	ISO/IEC15693	ID1	
iCLASS SE 32k (16k/16 + 16k/1)	HID Global	ISO/IEC15693	ID1	
MIFARE Classic 4k SE	HID Global	ISO/IEC14443 (Type A)	ID1	
MIFARE DESFire EV1 8k SE	HID Global	ISO/IEC14443 (Type A)	ID1	
iCLASS Seos AH	HID Global	ISO/IEC14443 (Type A)	ID1	
SE Configuration Card (JCOP)	HID Global	ISO/IEC14443 (Type A)	ID1	

7.4.4 Typical read ranges with HID multi-technology cards

For these read range tests, the serial number of each individual HF chip inside the multi-technology card was read. For Prox read ranges, see *Section 7.5 6500-101-03 Prox antenna*.

> **Note:** Read range varies depending on the transponder antenna size, design, SRF and Quality.

Card type	Manufacturer	Standard/modulation scheme	Format	Typical read range (mm)
MIFARE/Prox	HID Global	ISO/IEC14443 (Type A)	ID1	
DESFire/Prox	HID Global	ISO/IEC14443 (Type A)	ID1	
iCLASS Seos/Prox	HID Global	ISO/IEC14443 (Type A)	ID1	
iCLASS/Prox	HID Global	ISO/IEC15693	ID1	

7.4.5 Credential detection and read range

The credential detection range depends on the loading effect the transponder imposes on the OMNIKEY SE Reader Core's antenna during the credential detection operation. This means that transponders with lower loading effect will generally have a shorter detection range. The loading effect of a transponder will vary with the self-resonant frequency of the transponder, as well as the transponder type (e.g. memory card, smart card). The following table provides an overview of typical detection ranges with some transponders.

Note: Detection range may exceed usable read range for some credentials. The detection range can be reduced by increasing the HF credential detect threshold, if required.

Card type	Manufacturer	Size	Typical detection range (mm)	Typical detect and read range (mm)
iCLASS SR 2k/2	HID Global	ID1	97	
iCLASS SE 32k (16k/16 + 16k/1)	HID Global	ID1	97	
MIFARE Classic 4k SE	HID Global	ID1	65	
MIFARE DESFire EV1 8k SE	HID Global	ID1	55	
iCLASS Seos AH	HID Global	ID1	88	

Note: If the card detection range exceeds the actual read range, the reader may wake up but not read the transponder successfully at this distance. See the *Typical detect and read range* column for examples.

7.4.6 RF properties

Following is an overview of the RF properties of the 4090A10 HF antenna in combination with the OMNIKEY SE Reader Core. The modulation waveforms were measured at a distance of 12 mm (0.47"). Parameters may vary per unit due to component tolerances. The compliance of the modulation waveforms is an advantage to ensure interoperability with various transponders in the field. All measurements were performed in accordance with the ISO/IEC10373-6 standard.

Type A waveforms

Type A Fc/128 (106 kbps)	Condition	Minimum	Maximum	Measured value
T1 Pause length		28/fc	40.5/fc	
T2 Low time	t1 > 34/fc	7/fc	t1	
	t1 ≤34/fc	10/fc		
T3 Rise time to 90%		1.5xt4	16/fc	
T4 Rise time to 60%		0	6/fc	
Overshoot maximum		0	10%	

Type B waveforms

Type B Fc/128 (106 kbps)	Minimum	Maximum	Measured value
Modulation index	8%	14%	
Tr rise time	See ISO/IEC14443		
Tf fall time	See ISO/IEC14443		
Overshoot maximum	0	(1-tf/(2xtfmaxPCD))x0.1x(1-b)	
Undershoot minimum	0	(1-tr/(2xtrmaxPCD))x0.1x(1-b)	

FeliCa waveforms

FeliCa Fc/64 (212 kbps)	Minimum	Maximum	Measured value
Modulation index	8%	14%	
Tr rise time	n/a	2 µs	
Tf fall time	n/a	2 µs	
Overshoot maximum	n/a	0.1 (a-b) (10% modulation depth)	
Undershoot minimum	0.1 (a-b) (10% modulation depth)	n/a	

7.4.7 Power considerations

If the transponder is presented to the 4090A10 HF antenna, the impedance of the antenna will change. The magnitude of the impedance change depends on various factors such as:

- Geometrical relationship between the antennas (coupling).
- Distance.
- Impedance/power consumption of transponder.
- Enclosure (if any).

This leads to a change in power consumption of the reader. The following table provides an overview of power consumptions recorded with different transponders for a MK2 iCLASS SE Reader Module. Depending upon the coupling, a transponder placed on the surface of the antenna may produce high current consumption. An enclosure front provides separation to reduce this effect. A minimum distance of 3 mm (0.12") from the antenna surface to the transponder surface (for example, through an enclosure front) is recommended. Excessively recessing the antenna from the front of the enclosure is directly detrimental to performance by increasing the minimum separation unnecessarily. In a metallic enclosure, recessing the antenna lower than the front edge of the surrounding metal can severely impact performance too. Do not invoke HF RFID operations without an HF antenna fitted; doing so can result in significant current consumption. The measurements were taken with constant HF carrier enabled.

Mk2 2 iCLASS SE Reader Module			
Mode	**Parameter**	**Average**	**Unit**
iCLASS card in 10 mm (0.39") distance	VDC input supply current at 20°C (68°F), constant HF carrier enabled.	131	mA
iCLASS in 50 mm (2") distance		110	mA
iCLASS in 70 mm (2.8") distance		106	mA

7.5 4090A11 HF antenna (large antenna)

The 4090A11 HF antenna has a complex impedance and is optimized for operation with a 50 mm (2") ribbon cable. The antenna is tuned for a free-air environment.

7.5.1 Mechanical data

Detailed drawings are available at the OMNIKEY SE Reader Core micro-site.

7.5.2 Typical read ranges

Detect and/or read ranges vary with many factors such as reader antenna power, shape, size, enclosure type, enclosure material, mounting method, and card presentation method. Card antennas vary in shape, size, and position and may be asymmetrical within the card.

7.5.3 Typical read ranges with standard transponders

The following read ranges are for indication only. The read range of a transponder may vary significantly depending on antenna size and quality factor. Note that tests with other form factors like key fobs and tags were performed as well. The table shows ID1 cards only to allow direct comparison.

Card Type	Manufacturer	Format	Typical read range (mm)
iCLASS SR 2k/2	HID Global	ID1	
iCLASS SE 32k (16k/16 + 16k/1)	HID Global	ID1	
MIFARE Classic 4k SE	HID Global	ID1	
MIFARE DESFIRE EV1 8k SE	HID Global	ID1	
iCLASS Seos AH	HID Global	ID1	
SE Configuration Card (JCOP)	HID Global	ID1	

7.5.4 Typical read ranges with HID multi-technology cards

For these read range tests the serial number of each individual HF chip inside the multi-technology card was read.

> **Note:** Read range varies depending on the transponder's antenna size, design, SRF, and quality. The following applies to the 4090A11 HF antenna in free air.

Card type	Manufacturer	Standard / modulation scheme	Chip	Typical read range (mm)
MIFARE/Prox	HID Global	ISO/IEC14443 (Type A)	MIFARE	
DESFire/Prox	HID Global	ISO/IEC14443 (Type A)	DESFire	
iCLASS/Seos/Prox	HID Global	ISO/IEC14443 (Type A)	iCLASS Seos	
iCLASS/Prox	HID Global	ISO/IEC15693	iCLASS	

7.5.5 Credential detection range

Credential detection depends on the loading effect the transponder imposes on the OMNIKEY SE Reader Core's antenna. That means that cards with lower loading effect will generally have a shorter detection range. The following table provides an overview of typical detect and read range with selected credentials, where the credential has been both detected and also its CSN or data has been read.

Card type	Manufacturer	Size	Typical read range (mm)
iCLASS SR 2k/2	HID Global	ID1	
iCLASS SE 32k (16k/16 + 16k/1)	HID Global	ID1	
MIFARE Classic 4k SE	HID Global	ID1	
MIFARE DESFire EV1 8k SE	HID Global	ID1	
iCLASS Seos AH	HID Global	ID1	
SE Configuration Card (JCOP)	HID Global	ID1	

Notes:
Detection range may exceed usable read range for some credentials. The detection range can be reduced by increasing the HF credential detect threshold, if required.

If the card detection range exceeds the actual read range, the reader may wake but not read the transponder successfully at this distance.

7.5.6 RF properties ISO/IEC14443 Type A modulation waveforms

Provided is an overview on the RF properties of the 4090A11 HF antenna in combination with the OMNIKEY SE Reader Core. The modulation waveforms were measured at a distance of 12 mm (0.47"). Parameters may vary per unit due to component tolerances. The compliance of the modulation waveforms is essential to ensure the interoperability with various transponders in the field. All measurements were performed in accordance with the ISO/IEC10373-6 standard.

Type A waveforms

Type A Fc/128 (106 kbps)	Condition	Minimum	Maximum	Measured value
T1 pause length		28/fc	40.5/fc	
T2 low time	t1 > 34/fc	7/fc	t1	
	t1 ≤ 34/fc	10/fc		
T3 rise time to 90%		1.5xt4	16/fc	
T4 rise time to 60%		0	6/fc	
Overshoot maximum		0	10%	

Type B waveforms

Type B Fc/128 (106 kbps)	Minimum	Maximum	Measured value
Modulation index	8%	14%	
Tr rise time	See ISO/IEC14443		
Tf fall time	See ISO/IEC14443		
Overshoot maximum	0	(1-tf/(2xtfmaxPCD))x0.1x(1-b)	
Undershoot maximum	0	(1-tr/(2xtrmaxPCD))x0.1x(1-b)	

FeliCa waveforms

FeliCa Fc/64 (212 kbps)	Minimum	Maximum	Measured value
Modulation index	8%	14%	
Tr rise time	N/A	2 µs	
Tf fall time	N/A	2 µs	
Overshoot maximum	N/A	0.1 (a-b) (10% of modulation depth)	
Undershoot minimum	0.1 (a-b) (10% of modulation depth)	N/A	

7.5.7 Power considerations

If a transponder is presented to the 4090A10 HF antenna, the impedance of the antenna will change. The magnitude of the impedance change depends on various factors such as:

- Geometrical relationship between the antennas (coupling).
- Impedance/power consumption of transponder.

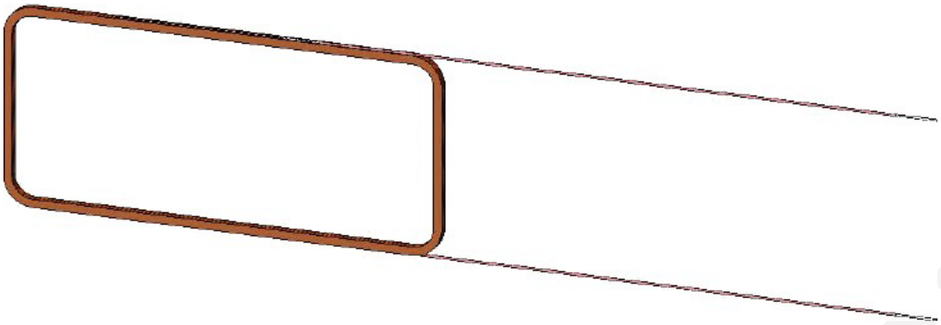
This leads to a change in power consumption of the reader. A minimum distance of 3 mm (0.12") from the antenna surface to the transponder surface (for example, through an enclosure front) is recommended, and more if possible.

The following table provides an overview of power consumptions recorded with different transponders. The measurements were taken with constant carrier on.

Mode	Parameter	Average	Unit
iCLASS card in 10 mm (0.39") distance	VDC input supply current at 20°C (68°F), constant HF carrier enabled.		mA
iCLASS in 50 mm (2") distance			mA
iCLASS in 70 mm (2.8") distance			mA

7.6 6500-101-03 Prox/LF (125 kHz) antenna

The OMNIKEY SE Reader Core is optimized for operation with this Prox/LF antenna. No external components are required.

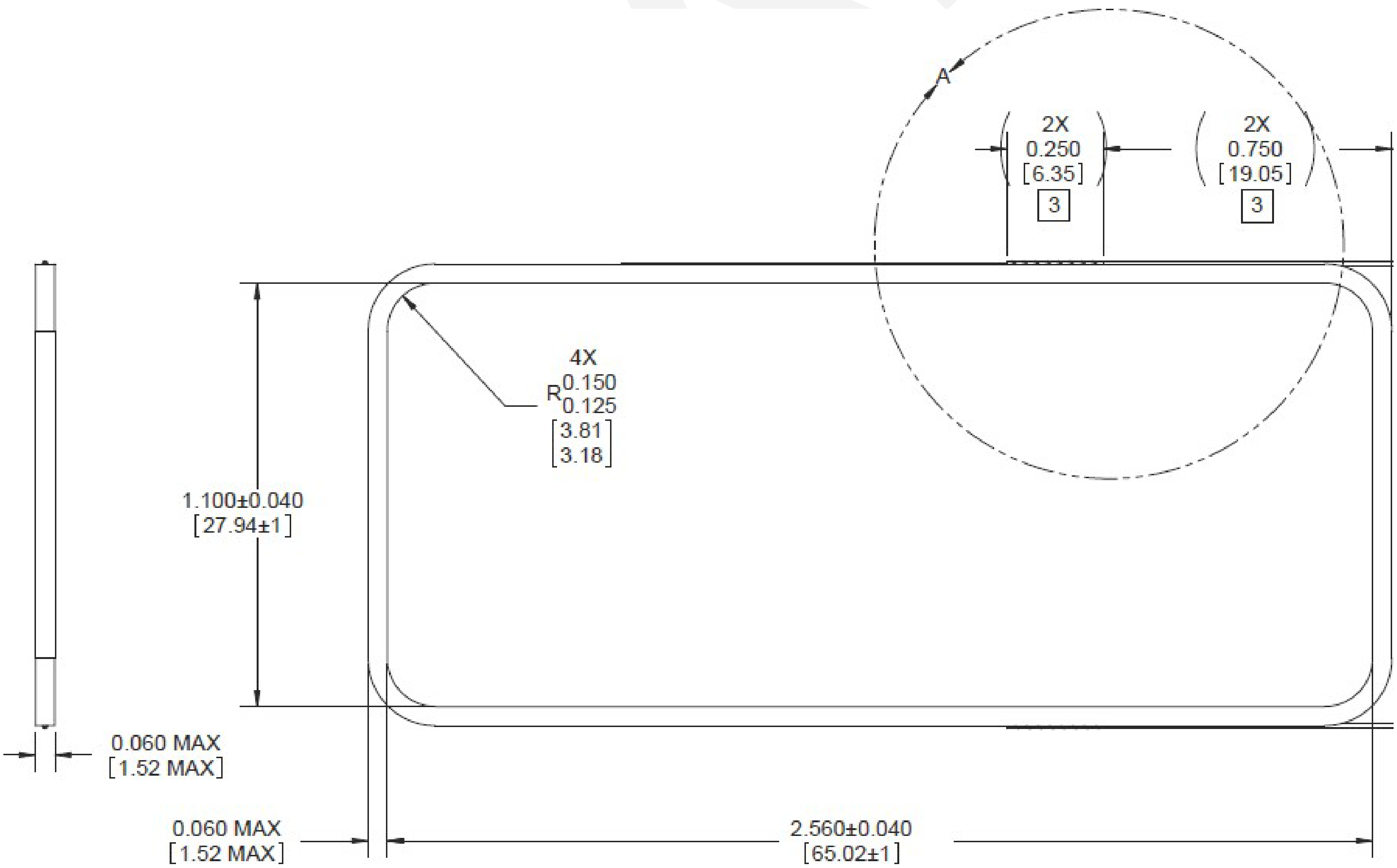


7.6.1 Mechanical data

Detailed drawings are available on the HID Developer Portal.

The antenna has two 76.2 mm 28AWG mag wire leads for interconnection to the OMNIKEY SE Reader Core. For soldering, a stripped end with 3.81 mm tinned is included.

Prox/LF antenna layout



7.6.2 Electrical characteristics

Parameter	Measurement frequency	Typ.	Unit
Number of turns		89	-
DC resistance		33	Ω
SRF		1	MHz
Inductance	1 kHz	800	µH
Impedance	50 kHz	29+j248	Ω
	100 kHz	31+j489	Ω
	500 kHz	50+j2674	Ω

7.6.3 Typical read ranges

Detect and/or read ranges vary with many factors such as reader antenna power, shape, size, enclosure type, enclosure material, mounting method, card presentation method. Card antennas vary in shape, size and position and may be asymmetrical within the card.

7.6.4 Typical LF read ranges

The measured read ranges are indications only. Read range varies due to transponder antenna size and quality, as well as environmental effects.

Transponder	Modulation scheme	Size	Typical read range (mm)
HID Proxcard™II	FSK	ID1	
HID DuoProx®II	FSK	ID1	
MIFARE/HID Prox Combo Card	FSK	ID1	
Indala Prox	PSK	ID1	
EM4102	ASK	ID1	

7.6.5 Typical LF credential detect and read ranges

The measured detect ranges are indications only. Read range varies due to transponder antenna size and quality, as well as environmental effects.

Transponder	Modulation scheme	Size	Typical read range (mm)
HID ProxcardII	FSK	ID1	
HID DuoProxII	FSK	ID1	
MIFARE/HID Prox Combo Card	FSK	ID1	
Indala Prox	PSK	ID1	
EM4102	ASK	ID1	

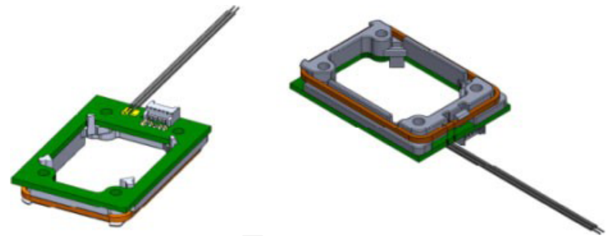
7.6.6 Prox antenna positioning

Positioning of the Prox antenna in the product should be carefully considered, bearing in mind the following points

- The antenna / OMNIKEY SE Reader Core combination is designed for a free-air scenario.
- Is both LF and HF credential reading required? Will the target area to present to the transponder be the same? Consider the 4090A16 HF/LF antenna instead, as it has a concentric pair of HF and LF antennas.
- The LF antenna will couple to an impinging HF antenna and alter the tuning of the HF antenna .
- Positioning must be accurate and consistent.

7.7 4090A16 SE Reader Core LF/HF antenna

This is an antenna that allows operation with both LF and HF credentials in an antenna concentric format. The antenna has been optimized in free-air for use with the OMNIKEY SE Reader Core. Performance of the antenna will decrease in the proximity of other conductive paths, especially if the path encompasses the antenna. The metal wound coil is the LF antenna.



Due to the antenna construction, when attached to an OMNIKEY SE Reader Core or iCLASS SE Reader Module SE32x0Bxx, both HF and LF credential detect operations (HF and LF pinging) can be used. However, when coupled to a SE32x0A iCLASS SE Reader Module, its HF credential detect operation is not supported (and that module does not have LF credential detect circuitry). Do not use this antenna if ULPM (credential detection) operation is needed with a SE32x0A iCLASS SE Reader Module.

	OMNIKEY SE Reader Core	SE32x0B Reader Module	SE32x0A Reader Module
HF credential detect possible?	Yes	Yes	No
LF credential detect possible?	Yes	Yes	No

Due to the dual-antenna construction, credential detect performance may be reduced compared with that of a single dedicated HF or dedicated LF antenna.

In a product, the antenna can be installed either way up, and the orientation will affect the detect and read range experience, as either the HF or the LF antenna will be nearest the active surface of that product. Careful testing should be carried out to ensure best overall performance in line with requirements.

7.7.1 Connecting the antenna

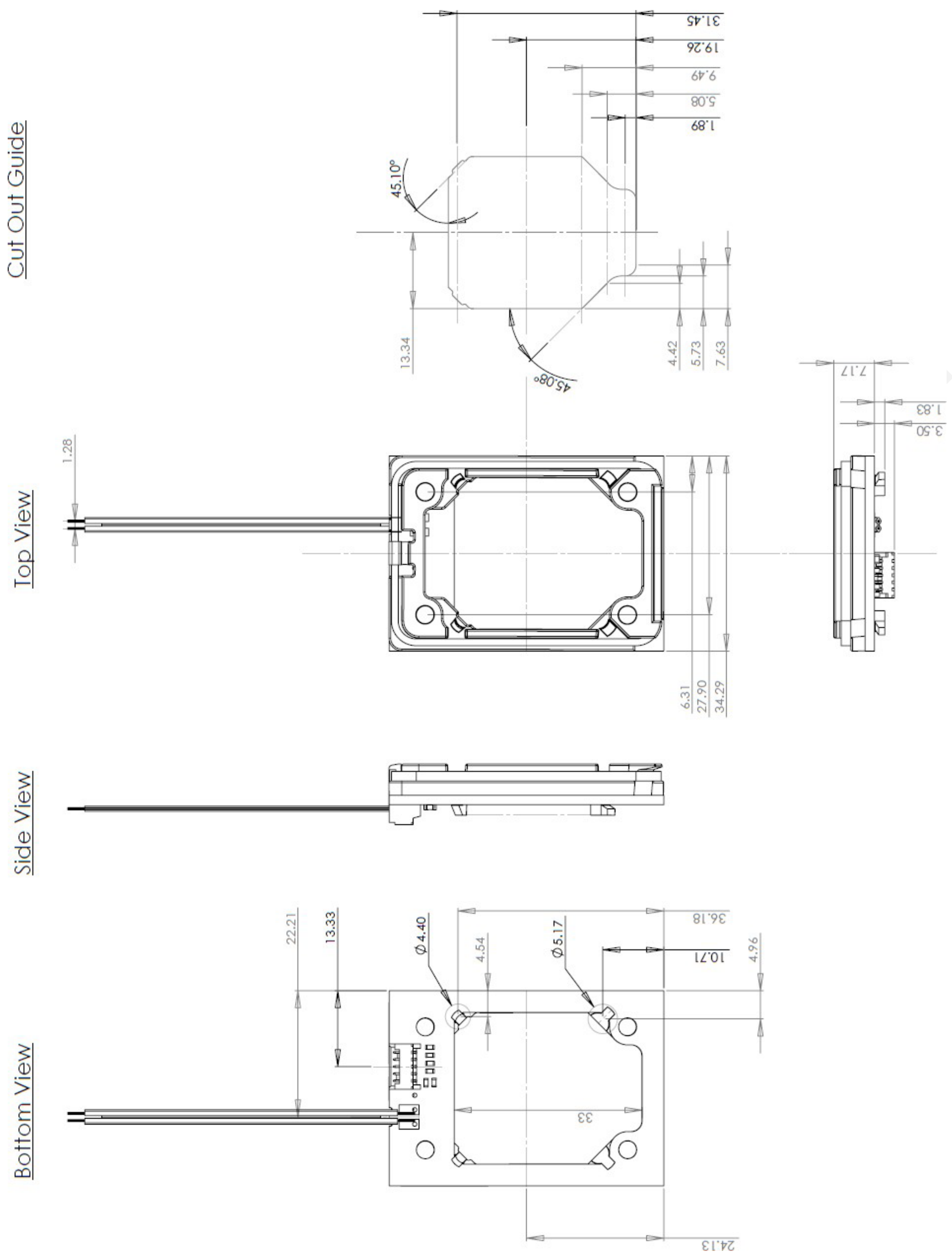
The appropriate standard 5-way HF antenna cable can be used to connect the HF part of the LF/HF antenna to the appropriate OMNIKEY SE Reader Core Mini/Standard. The antenna comes with a pre-attached pair of LF connection wires. These LF wires can be shortened if required.

7.7.2 Positioning the antenna

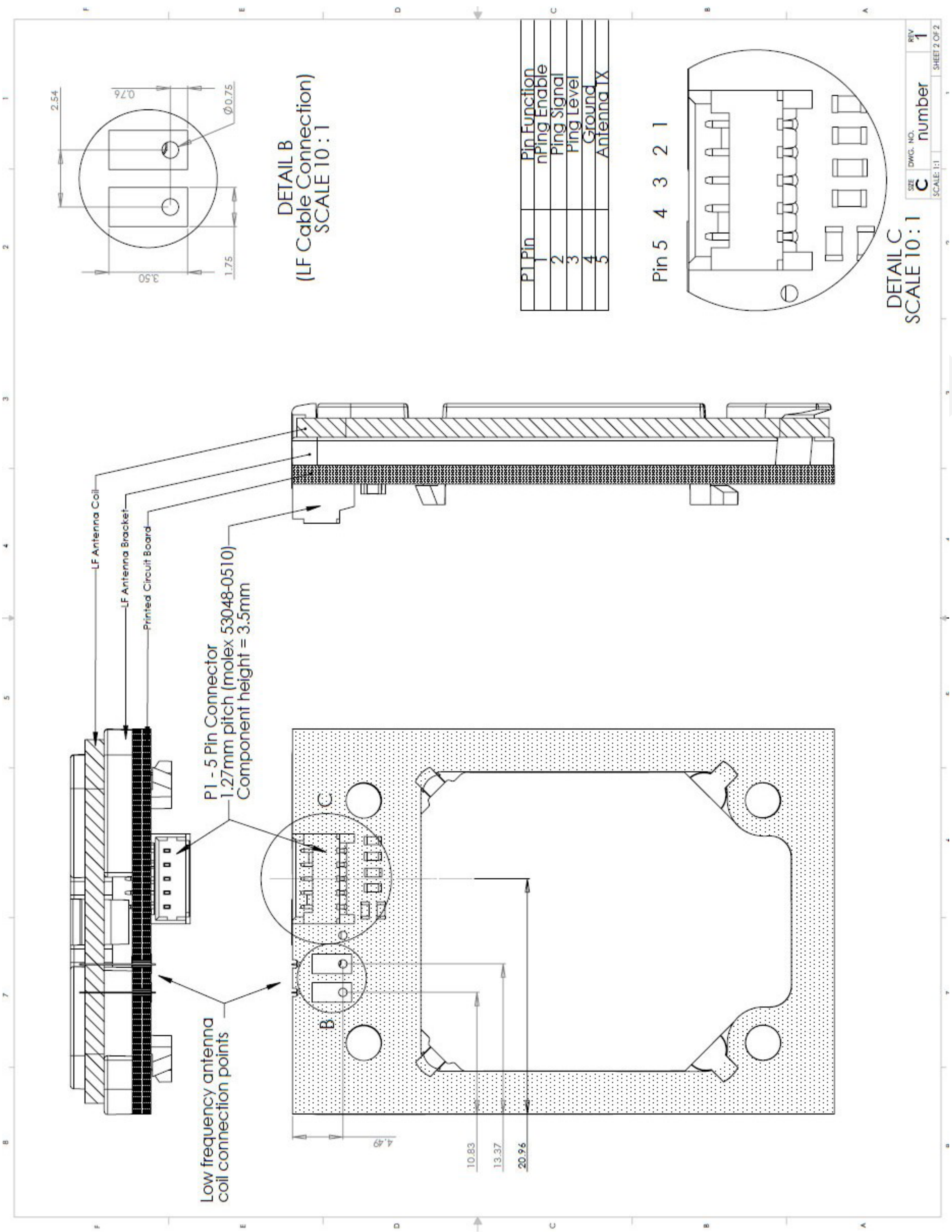
The antenna is designed for free-air usage. Placing it near or above or below a circuit board, particularly one with a ground or power plane(s), will degrade performance. Similarly, placing the antenna within or at the bounds of a continuous periphery metal object, even one with a plastic aperture in front of the OMNIKEY SE Reader Core, such as an enclosure, will degrade performance. This will differ depending on the distances between the antenna and the metal edges/surfaces. The larger the gap between the enclosure and the antenna the better.

> **Note:** This also applies in the z (vertical) dimension. A keyboard in front of the antenna OMNIKEY SE Reader Core may degrade performance, in addition to any physical recessing of the OMNIKEY SE Reader Core from the front of the enclosure.

Dual HF/LF antenna PCBA scale drawing



LF antenna and cable detail drawing



7.7.3 Typical read ranges

Detect and/or read ranges vary with many factors such as reader antenna power, shape, size, enclosure type, enclosure material, mounting method, card presentation method. Card antennas vary in shape, size and position and may be asymmetrical within the card. The measured read ranges are indications only.

LF transponder - polling

Transponder	Modulation scheme	Size	Typical read range(mm)
HID ProxcardII	FSK	ID1	
HID DuoProx II	FSK	ID1	
iCLASS/HID Prox Combo Card	FSK	ID1	
Indala Prox	PSK	ID1	
EM4102	ASK	ID1	

LF transponders - detect and read range (detection may occur at a greater distance)

Transponder	Modulation scheme	Size	Typical read range(mm)
HID ProxcardII	FSK	ID1	
HID DuoproxII	FSK	ID1	
iCLASS/HID Prox Combo Card	FSK	ID1	
Indala Prox	PSK	ID1	
EM4102	ASK	ID1	

HF transponders - polling

Card type	Manufacturer	Size	Typical read range (mm)
iCLASS SR 2k/2	HID Global	ID1	
iCLASS SE 32k (16k/16 + 16k/1)	HID Global	ID1	
MIFARE Classic 4k SE	HID Global	ID1	
MIFARE DESFire EV1 8k SE	HID Global	ID1	
iCLASS Seos AH	HID Global	ID1	
SE Configuration Card (JCOP)	HID Global	ID1	

HF transponders - detect and read range (detection may occur at a greater distance)

Card type	Manufacturer	Size	Typical read range (mm)
iCLASS SR 2k/2	HID Global	ID1	
iCLASS SE 32k (16k/16 + 16k/1)	HID Global	ID1	
MIFARE Classic 4k SE	HID Global	ID1	
MIFARE DESFire EV1 8k SE	HID Global	ID1	
iCLASS Seos AH	HID Global	ID1	
SE Configuration Card (JCOP)	HID Global	ID1	

7.7.4 Electrical characteristics

The 4090A16 LF/HF antenna is designed to be compatible with the OMNIKEY SE Reader Core.

7.7.5 HF Field strength characteristics

Parameter	Value	Average	Unit
Distance	0	15	mm
Field strength			A/m

7.7.6 Current consumption characteristics with OMNIKEY SE Reader Core

Current consumption of the system will vary when a credential is presented to the antenna face, depending on the size and type of the credential and its positioning, and to an extent upon the ambient temperature and supply voltage.

Some indicative figures are shown below; these figures are not representative outside of a free-air environment.

Operating condition					Units
		3.6	5.0	6.0	V
Temperature -25°C (-13°F)					
Configuration card poll only					mA
Continuous HF	No credential				mA
	All plate				mA
Credential detect					µA
Temperature 20°C (68°F)					
Configuration card poll only					mA
Continuous HF	No credential				mA
	All plate				mA
Credential detect					µA
Temperature 70°C (158°F)					
Configuration card poll only					mA
Continuous HF	No credential				mA
	All plate				mA
Credential detect					µA

7.7.7 RF properties ISO/IEC14443

Provided is an overview on the RF properties of the 4090A16 LF/HF antenna in combination with the OMNIKEY SE Reader Core. The modulation waveforms were measured at a distance of xx" (xx mm). Parameters may vary per unit due to component tolerances. Waveform capture illustrations are provided in **Waveform modulation data: 14443A, B**.

All measurements were performed in accordance with the ISO/IEC10373-6 standard.

Type A waveforms

Type A Fc/128 (106 kbps)	Condition	Minimum	Maximum	Measured value
T1 Pause length		28/fc	40.5/fc	
T2 Low Time	t1 > 34/fc	7/fc	t1	
	t1 ≤ 34/fc	10/fc		
T3 Rise Time to 90%		1.5xt4	16/fc	
T4 Rise Time to 60%		0	6/fc	
Overshoot maximum		0	10%	

Type B waveforms

Type B Fc/128 (106 kbps)	Minimum	Maximum	Measured value
Modulation Index	8%	14%	
Tr Rise Time	See ISO/IEC14443		
Tf Fall Time	See ISO/IEC14443		
Overshoot maximum	0	(1-tf/(2xtfmaxPCD))x0.1x(1-b)	
Undershoot maximum	0	(1-tr/(2xtrmaxPCD))x0.1x(1-b)	

FeliCa waveforms

FeliCa Fc/64 (212 kbps)	Minimum	Maximum	Measured value
Modulation Index	8%	14%	
Tr Rise Time	N/A	2 µs	
Tf Fall Time	N/A	2 µs	
Overshoot maximum	N/A	0.1 (a-b) (10% of modulation depth)	
Undershoot minimum	0.1 (a-b) (10% of modulation depth)	N/A	

7.7.8 Mechanical data

Detailed drawings are also available on the HID Developer Portal.

7.8 Bluetooth Low Energy interface (2.44 GHz)

7.8.1 Overview

Bluetooth Low Energy is an optional part of Bluetooth 4.0. It is a white paper design, meaning that no burdens from the classic Bluetooth design were taken over. The technology is optimized for lowest power consumption.

The following table provides a comparison between classic Bluetooth with base/enhanced data rate and Bluetooth Low Energy.

Feature	Classic (BR/EDR)	Bluetooth Low Energy	Notes
RF channels	79	40	2 MHz spacing in Bluetooth Low Energy
Modulation	GFSK	GFSK	Simple and effective
Modulation index	0.25 to 0.35	0.45 to 0.55	Wider signal, more robust
Max Tx power	+20 dBm (class1) +4 dBm (class 2)	+10 dBm +6 dBm[1] (typical, OMNIKEY SE Reader Core)	No "class" structure +10 dBm regulatory limit
Rx sensitivity	-85 dBm	-85 dBm -96 dBm[2] (OMNIKEY SE Reader Core)	Pathloss 90 dB for BR Pathloss 95 dB for Bluetooth Low Energy
Typical range	30 m	50 m	Modulation index, increased power for class 2
Max. data rate	2178.1 kb/s	305 kb/s	EDR much faster

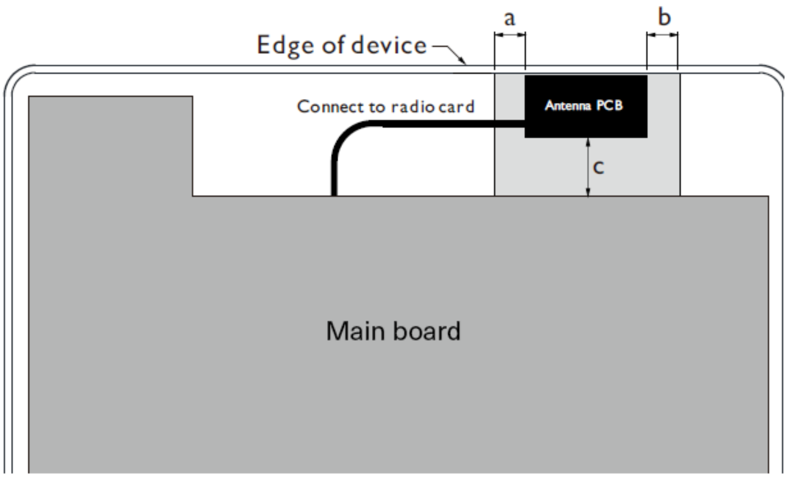
1. 1 Mbps data rate
2. 1 Mbps data rate. Ideal transmission source.

7.8.2 Bluetooth Low Energy antenna

A third-party Bluetooth Low Energy antenna must be used, attached by a short coax cable. A recommended antenna is detailed below.

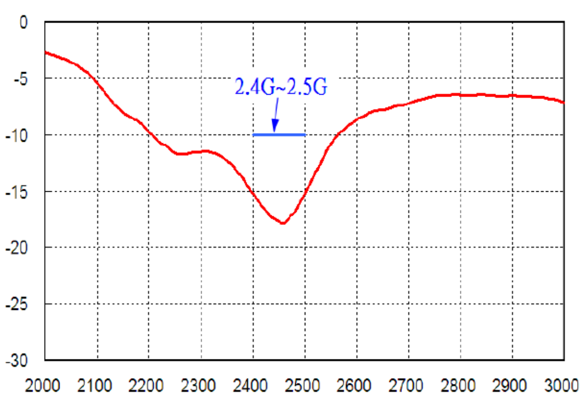
Manufacturer	Yageo
Manufacturer part	ANTX200P001B24003
Working frequency	2.4-2.5 GHz
VSWR	2.0: 1 max
Peak gain	4.4 dBi (typ.)
Polarization	Linear
Radiation pattern	Omnidirectional
Impedance	50 Ω nominal
Operating temperature	-40 to 85°C (-40 to 185°F)
Maximum power	1 W
PCB dimensions	18.4 mm × 7.5 mm × 0.55 mm (0.72 in × 0.3 in × 0.02 in)
Radio connector	I-PEX (20278-112R-13)
Cable diameter / length / color	1.13 mm / 200 mm / black
Mounting	Adhesive tape (HF-DS)

Antenna element should be placed at the edge of the device, with minimum clearance from metallic objects of a = 5 mm, b = 5 mm, c = 10 mm, as shown in the following diagram:



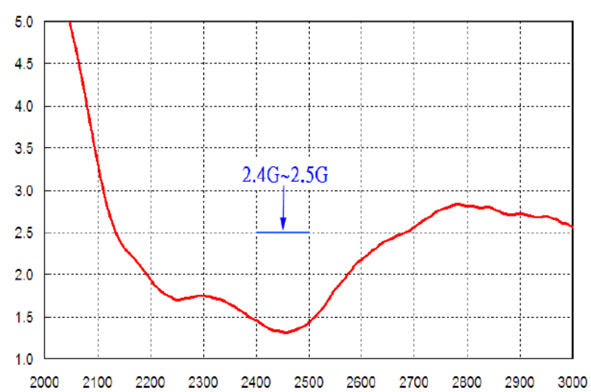
Return loss and VSWR measurement

Return loss (dB)



Frequency (MHz)

VSWR

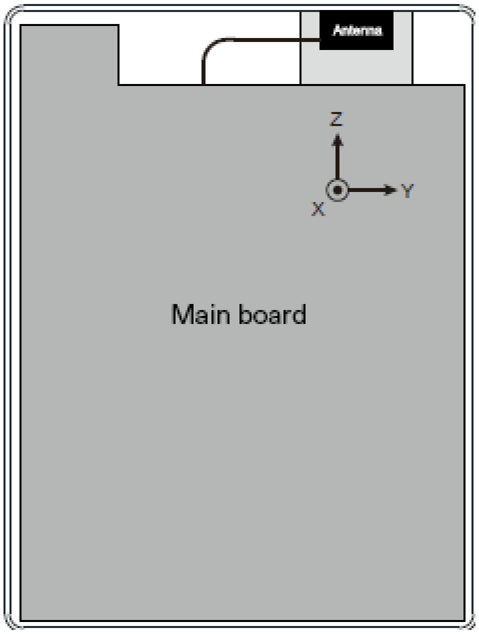


Frequency (MHz)

Antenna gain and efficiency

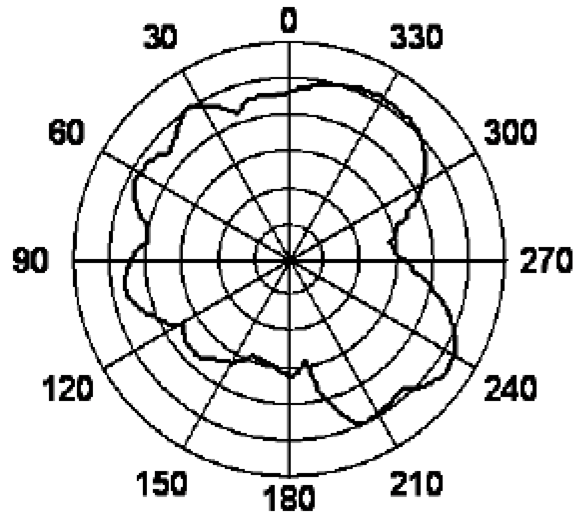
Frequency (GHz)	Average gain (dBi)	Efficiency (%)	Peak gain (dBi)
2.40	-2.1	62	4.0
2.45	-2.2	61	4.4
2.50	-3.0	50	4.1

Antenna radiation pattern

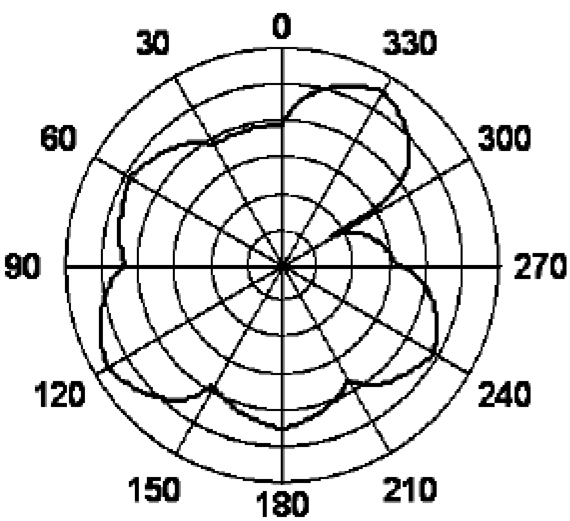


Device setup and coordinates

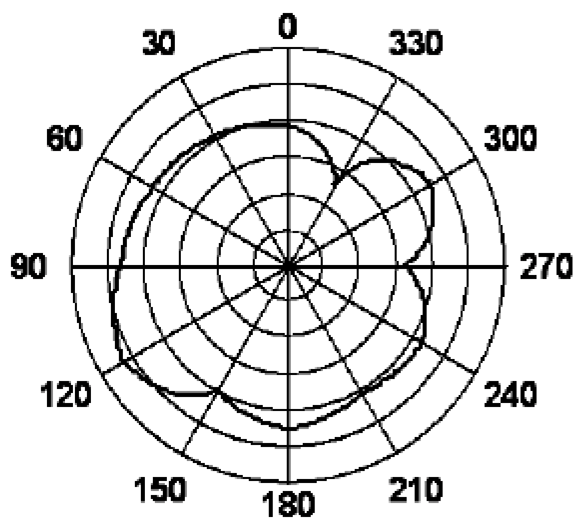
Scale: 5 dBi/div. Max: 5 dBi, Min: -25 dBi



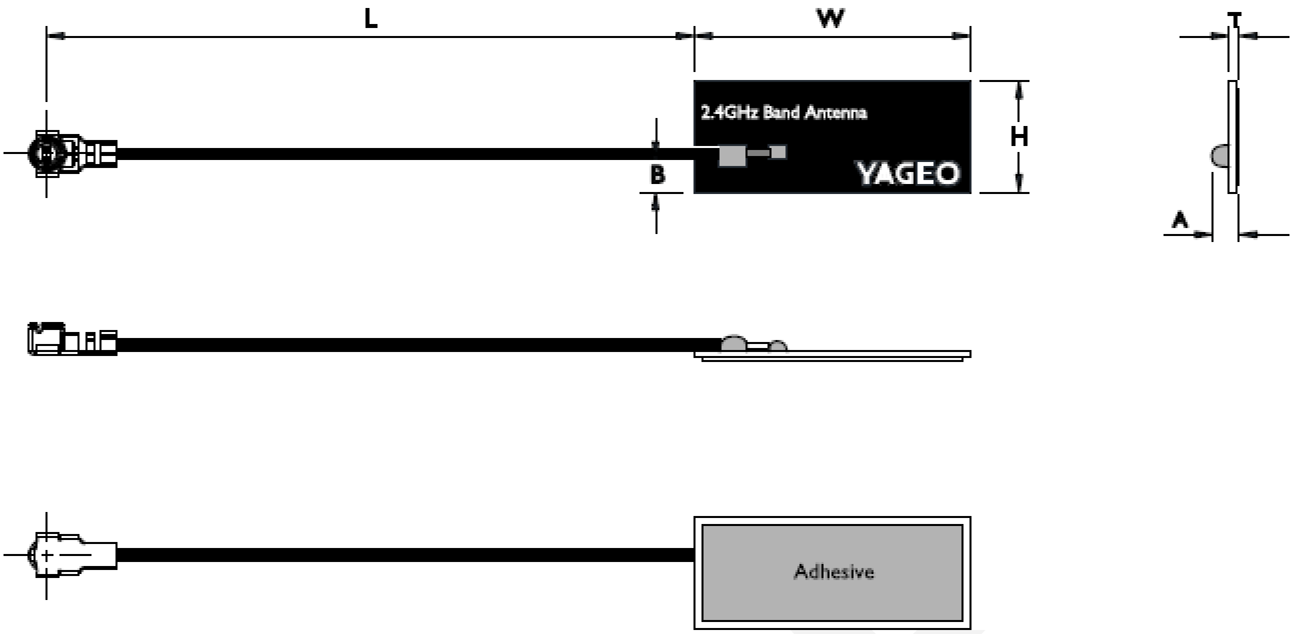
X-Y plane



X-Z plane



Y-Z plane



Dimension	Value (mm)
L	200 ±3.00
W	18.40 ±0.30
H	7.50 ±0.30
T	0.55 ±0.15
A	2.30 maximum
B	1.80 ±1.00

7.8.3 Bluetooth Low Energy typical RF configuration

Reader TX power	-4 dBm
Twist & Go RSSI threshold	-74 dBm
Tap RSSI threshold	-40 dBm

Note: This configuration should be modified to regulate read range in a final application. The impact of changes on read range may vary depending on phone model and/or installation environment. For more information on the configuration, see *HID Mobile Access Configuration Application Note* (PLT-02075).

7.8.4 Bluetooth Low Energy typical read range

Read range depends upon the choice of third-party Bluetooth Low Energy antenna and its installation. Ranges up to 12 m have been observed in an outdoor environment. Performance is also mobile device dependent, with differences between manufacturers and individual models.

Note: Not all phones are supported by HID Mobile Access. For supported devices, see *HID Mobile Access Solution Overview* (PLT-02078).

Section 08

Regulatory

8.1 RoHS

The OMNIKEY SE Reader Core RoHS declaration is available on the HID Developer Portal.

8.2 REACH

The OMNIKEY SE Reader Core REACH letter is available on the HID Developer Portal.

8.3 Safety - for indoor use only

The following describes OMNIKEY SE Reader Core regulatory guidelines:

- UL Recognition (Recognized Component) to UL294 for the USA and CSA C22.2 No. 205 for Canada. The mark is cRUus where the R is backwards.
- OEM Final Product UL Listing. As HID Reader Cores are CUL recognized, UL treats them as a recognized component and therefore must be evaluated by UL in the final product for UL Listing.
- Transient surge protection (transorbs) is not provided for the OMNIKEY SE Reader Core with the exception of the USB interface.
- The OMNIKEY SE Reader Core is intended to be part of a reader. The reader in which the OMNIKEY SE Reader Core is used must translate the 3 VDC OMNIKEY SE Reader Core Voh signaling to 4 - 5.5 VDC Voh SIA AC-01 (1996.10) signaling requirements.

The UL file for the OMNIKEY SE Reader Core is <<TBD>> (previously BP6568), Category Code ALVY2. View from the public UL Directory at: **http://database.ul.com/cgi-bin/XYV/template/LISEXT/1FRAME/index.htm** (requires login).

8.4 CE/UKCA Marking

HID Global hereby declares that these proximity readers are in compliance with the essential requirements and other relevant provisions of Directive 1999/5/EC and 2006/95/EC.

Por el presente, HID Global declara que estos lectores de proximidad cumplen con los requisitos esenciales y otras disposiciones relevantes de la Directiva 1999/5/EC and 2006/95/EC.

HID Global déclare par la présente que ces lecteurs à proximité sont conformes aux exigences essentielles et aux autres stipulations pertinentes de la Directive 1999/5/CE and 2006/95/EC.

A HID Global, por meio deste, declara que estes leitores de proximidade estão em conformidade com as exigências essenciais e outras condições da diretiva 1999/5/EC and 2006/95/EC.

HID Global bestätigt hiermit, dass die Leser die wesentlichen Anforderungen und anderen relevanten Bestimmungen der Richtlinie 1999/5/EG erfüllen and 2006/95/EC.

HID Global dichiara che i lettori di prossimità sono conformi ai requisiti essenziali e ad altre misure rilevanti come previsto dalla Direttiva europea 1999/5/EC and 2006/95/EC.

Download copies of the R&TTE Declaration of Conformity (DoC) at:

http://www.hidglobal.com/certifications

8.5 Product radio certifications

The OMNIKEY SE Reader Core was tested under the FCC and Industry Canada rules for a Modular Approval and therefore the following shall apply (reference below FCC/IC ID).

- Provided that the antenna, antenna to OMNIKEY SE Reader Core cable, and tuning network have not been changed in any way; the final product label may contain the FCC ID, provided no other radio devices exist within the final assembly.
- The End User/Manufacturer, will not need to repeat the intentional emissions testing (actual radio certification), however the unintentional emissions testing will need to meet the FCC and IC requirements with the OMNIKEY SE Reader Core installed into the final assembly or product. This also applies to CE/UKCA Marking as defined by the R&TTE Directive.
- However, in many cases, the OMNIKEY SE Reader Core may need to be retuned, due to the effects of the product enclosure and assemblies within this enclosure, and the de-tuning effect that this may have on the radio circuitry. In this case and if other radios exist, C2PC is required.
- In the event that the OMNIKEY SE Reader Core kit is modified in any way, the radio transmitter operating at either 125 kHz or 13.56 MHz and the OMNIKEY SE Reader Core is integrated into the OEM's final product, Radio Certification is required for the final product.
- Obtain FCC Certification by submitting the final product to a Telecommunications Certified Body (TCB) laboratory that performs the testing and issue the FCC Grant. Standard: Part 15, Subpart C.

RCS55100000	RCL55100000
FCC ID: JQ6-SE3200<<TBD>>All four table entries are struck out in Word source document?	FCC ID: J6-SE3210
IC ID: 2236B-SE3200	IC ID: 2236BSE3210

- Often the same TCB tests to Canada requirements and grants certification as a Certification Body (CB). Standard: RSS-210, RSS-GEN and RSS-310, where applicable.
- The same laboratory may also be an EU Communications Assessment Body (CAB) that is accredited to test to R&TTE Directive requirements for CE/UKCA Marking. Standards: EN 300 330, EN 301 489-3, EN 50130- 4, and IEC60950.
- A laboratory that is CAB testing to R&TTE Directive requirements will also be testing to Australia and New Zealand requirements because of a common test standard. Standard: AS/NZS 4268.
- Asian country certifications are obtained on an individual country basis.

OEM Final Product US Dept. of Commerce Bureau of Industry and Security (BIS) approval is required for USA based companies who export and re-export products using encryption.

8.5.1 Regulatory compliance assistance

HID global provides technical assistance and laboratory recommendations, as required.

> **Important: Any changes or modifications to this device not explicitly approved by the manufacturer could void your authority to operate this equipment.**

8.6 FCC

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

8.7 Canada Radio Certification

This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Appendix A

Waveform modulation data: 14443A, B

A.1 Waveform captures

Waveform captures from modulation compliance testing with the OMNIKEY SE Reader Core are shown in this section. Waveforms were captured at the stated distance from the antenna, in free air, and according to ISO 10373-6 methods. The Reference PICC antenna class used is detailed along with the results. Where the standard Reference PICC pick-up antenna was insufficient to capture the waveform, a separate pick-up antenna was used.
Small (part 4090A10), Large (part 4090A11), and Dual LF/HF (part 4090A16) antenna results are provided.

A.1.1 ISO 14443A 106 kbps. Small antenna (4090A10)

(Awaiting image)

A.1.2 ISO 14443B 106 kbps. Small antenna (4090A10)

(Awaiting image)

A.1.3 ISO 14443A 106 kbps. Large antenna (4090A11)

(Awaiting image)

A.1.4 ISO 14443B 106 kbps. Large antenna (4090A11)

(Awaiting image)

A.1.5 ISO 14443A 106 kbps. Dual LF/HF antenna (4090A11)

(Awaiting image)

A.1.6 ISO 14443B 106 kbps. Dual LF/HF antenna (4090A11)

(Awaiting image)

Revision history

Date	Description	Revision
October 2022	Initial release.	A.0

hidglobal.com

For technical support, please visit: https://support.hidglobal.com

PLT-06447, Rev. A.0

Part of ASSA ABLOY