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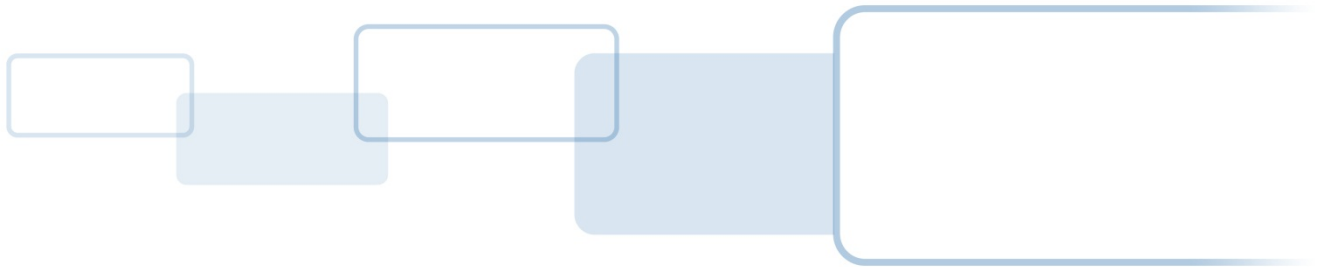
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iCLASS SE Reader Module

HARDWARE DEVELOPER GUIDE

SE3200-902, Rev B.0

October 2012

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1 Introduction

1.1 Product Description

The iCLASS SE® Reader is part of HID Global's next generation platform. The iCLASS SE Reader goes beyond the traditional smart card model offering secure and standards based independent technology and flexible identity data structure based on Secure Identity Object™ (SIO®). SIO is a portable and open credential methodology.

Building on the success of the existing OEM modules (including the OEM50 and OEM75) the iCLASS SE Reader enhances existing functionality with new SIO features. The new features include supporting NFC smartphones and other devices for mobile access while also providing increased levels of security.

The iCLASS SE Reader allows integrators to design third party solutions supporting a full range of contactless card technologies, including iCLASS®, MIFARE® and HID Prox. It also provides PIV II compliance/ FIPS 201 certification and appears on the GSA Approved Products List (APL) allowing straightforward integration into U.S. Government applications.

The iCLASS SE Reader's dual frequency capability allows the use of both high and low frequency credentials with the same reader, providing a solution for mixed credential and credential migration applications.

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

For quick and easy integration, HID Global also provides an iCLASS SE Reader 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.

1.1.1 Key Features

- Single platform supporting
  - Secure Identity Object – Multi Layer security that extends beyond the card technology, providing additional protection to identity data
  - Dual Frequency and NFC Capability – Allows straightforward migration by supporting low and high frequency credentials (including iCLASS®, HID Prox, Indala Prox, FeliCa™ MIFARE® Classic and MIFARE DESFire® EV1) and NFC enabled smartphones.
  - Field upgradeability giving the installer the flexibility to implement new features in the field and extending product lifecycle
- A complete flexible product line of reader boards, antennas and accessories.
- Developer tools and support. iCLASS SE Reader provides a fully featured Development Tool Kit (DTK) providing web / desktop based tools and documentation.
- Development support from HID Global Support Services
- Product pre-certification for industry standard bodies such as modular-FCC and CE
- FIPS 201 PIV II compliance with inclusion on the GSA APL

- Ultra low power mode for battery- operated devices
- EAL5+ certified secure element hardware for protection of keys and cryptographic operations to guard against security threats

1.1.2 iCLASS SE Reader Module Products

The iCLASS SE Reader Module comes in two form factors.

- 3200 iCLASS SE Reader Module

  Same form factor as OEM50
  28mm x 30.5mm (1.10" x 1.20")

- 3210 iCLASS SE Reader Module

  Same form factor as eProx-Lock module
  33mm x 43mm (1.3" x 1.7")

Development Tool Kit

- Development Board
- 3200 and 3210 iCLASS SE Reader Modules
- HF and LF Antennas and cables
- Sample Credentials
- Memory Stick containing development tools and documentation

1.1.3 Product Guide

The iCLASS SE reader module comes in two form factors. It can also be configured for high frequency card reading only or High & low frequency (prox).

In addition there are two different levels of security provided.

Key Security Notes:

Standard V1 Security: Standard Security (Version 1) Keyset – coupled with the Standard 13.56 MHz interpreter provides compatibility with iCLASS SE, iCLASS SR, standard iCLASS, SE for MIFARE Classic and SE for MIFARE DESFire EV1 credentials.

Standard V2 Security: Standard Security (Version 2) Keyset – coupled with the SIO (Only) 13.56 MHz interpreter provides compatibility with iCLASS SE, MIFARE Classic SE and MIFARE DESFire EV1 SE credentials

Elite Security: Elite reads only SE Elite™ credentials with unique matching keys. Works with iCLASS SE, iCLASS SR, standard iCLASS, SE for MIFARE Classic and SE for MIFARE DESFire EV1 with matching Elite keys. Requires ICE reference number.

Prox Reading Notes:

Standard Prox: HID Prox, AWID, EM4102 and Indala (10022 – 26-bit)

Custom Prox: HID Prox, AWID, EM4102 and Indala Custom format

For full ordering information including options, see the Embedded Technology Solutions How to Order Guide: http://www.hidglobal.com/documents/embedded_htog_en.pdf.

1.2 Scope/Purpose

This document describes the hardware features of the iCLASS SE Reader Module. The product is available in two form factors with various different configurations. Form factor and host connectors are backward compatible to the OEM75 module.

1.3 Terms and Abbreviations

Abbreviation	Description
ANT	Antenna
ARM	Advanced RISK Machine
CSN	Card Serial Number
DNC	Do Not Connect
EMC	Electro Magnetic Compatibility
FSK	Frequency Shift Keying
FCC	Federal Communication Commission
HF	High Frequency (13.56 MHz)
LED	Light Emitting Diode
NPM	Normal Power Mode
PICC	Proximity IC Card

Abbreviation	Description
FeliCa	Felicity Card
IC	Industry Canada (Industrie Canada)
I/O	Input / Output
LF	Low Frequency (125 kHz)
Optimized	Configured/Developed to operate at the best performance level
RF	Radio Frequency
RFID	Radio Frequency Identification
R&TTE	Radio and Telecommunications Terminal Equipment
SIO	Secure Identity Object
SPI	Serial Peripheral Interface
Ta	Ambient Temperature
TTL	Transistor – Transistor Logic
UART	Universal Asynchronous Receiver Transmitter
UID	Unique Identifier
UL	Underwriters Laboratories
USB	Universal Serial Bus
ULPM	Ultra Low Power Mode

2   Overview

2.1   Features

Table 1: Feature Overview

Type	Feature	Comment
RF Interface	ISO/IEC14443	ISO/IEC14443 Type A&B up to 848kbps, 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
	FeliCa	CSN only
	HID Prox	SE32x0APx only
	Indala Prox	
Host Interfaces	SPI	
	UART	Suggested host interface
	Wiegand	Output only binary interface
Environmental Properties	Operating Temperature	-25°C to 65°C
	Storage Temperature	-45°C to 85°C
	Humidity	0-90% non condensing
Certifications	FCC & IC	FCC and Industry Canada Modular Approval
	CE Marking	R&TTE Directive (Emissions, Indirect ESD, RF Immunity)
	RoHS & REACH	
	UL Recognized Component	UL 294 (in process)
	GSA	SE32x0Axx-G3.0 only (in process)

2.2 Block Diagram
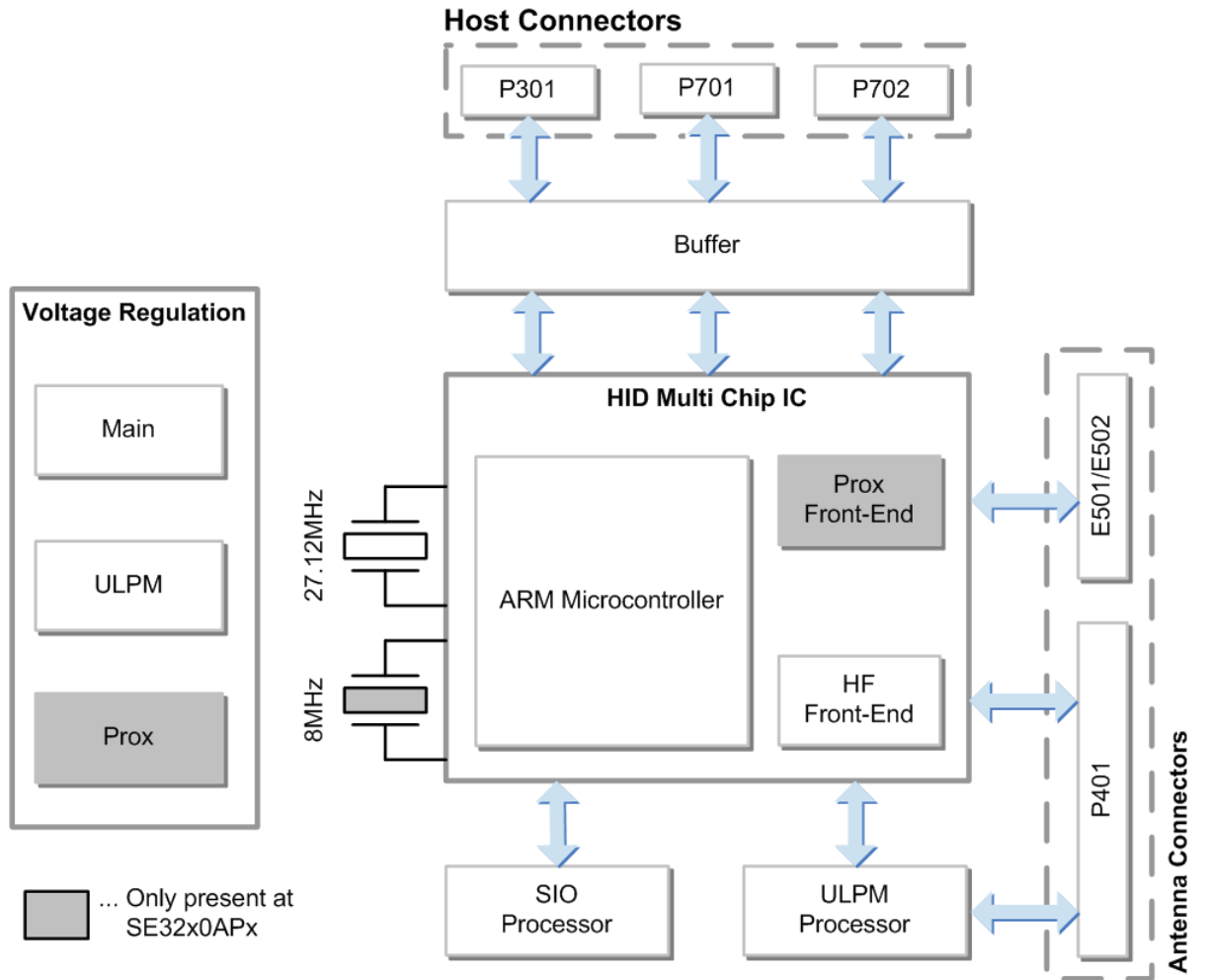
Figure 1: iCLASS SE Reader Module Block Diagram

2.3 Theory of Operation

2.3.1 Power Modes

- **Normal Power Mode** (NPM) – The module is constantly powered on and polling for cards. The module is never asleep in this mode. Use this mode with an external power supply. The module is always ready to receive a command from the host.

- **Ultra Low Power Mode** (ULPM) – This power mode was designed for fixed location battery powered applications (for example, door or cabinet lock). The module is constantly monitoring the antenna for an impedance shift to detect a card presented to the antenna. Once detecting an impedance shift on the HF antenna, the module wakes up and polls for cards in the field. If a card is detected in the RF field, the module reads the card data, pulses the Card Present line, outputs the card data, and goes back to sleep within a configured period of time to conserve power.

Note: If developing a handheld unit, operate the iCLASS SE Reader Module in Normal Power Mode and disable the power when not in use.

Power	Autonomous Mode	Autonomous & API Mode
NPM	✓	✓
ULPM	✓	after autonomous output

2.3.2 Module – Transponder Interaction

- **Autonomous Mode** – The iCLASS SE Reader Module is intended to automatically access and report the secure payload or the serial number (UID/CSN) of a transponder. Thereby it acts on its protocols and applications configuration to automatically report the payload on its Wiegand, UART and/or SPI ports.

  Advanced Protocol Interface Mode (API) – The host communicates with the transponder in the field through the iCLASS SE Reader Module's serial protocol. (UART or SPI is required)
  Note: API calls are available in ULPM after the module outputs its autonomous data (configuration dependant).

2.4 Peripheral Circuits

The following section details recommended peripheral circuitry.

2.4.1 External Pull-up Resistors

External pull-up resistors may be required on the UART Tx and MOSI lines to prevent floating I/O anomalies.

2.4.2 External Noise Filter

If false card detections occur in Ultra Low Power mode, or the host has spectral noise, a line filter designed to block frequencies in the 10 KHz to 50 KHz range is beneficial when inline with the power line.

2.4.3 Adding External LEDs and Beeper

The Cathodes are connected through an external resistor to the RED or GREEN LED connector port signals. The OEM supplies current limiting resistors for modules.

The value of these resistors depends on how much current is provided for the LEDs. Consider the combined voltage drop of the resistor and OEM75 output low voltage on these signal lines when selecting the LED brightness.

2.5 Transitioning from the OEM50, OEM75 and eProxL Modules

Provided are suggestions for transitioning from the HID OEM50 and eProx Lock modules to the OEM75.

2.5.1 OEM50

If you are transitioning from an OEM50 – here are the differences.

- The OEM50 connector is a 2 X 6 0.1" space pin header or PWB hole pattern.

- The OEM50 has a two-wire interface to the antenna and the iCLASS SE Reader has a 2-wire interface for NPM and a 5-wire interface for ULPM applications. Therefore, it is possible that the OEM50 antenna will work with the SIO Processor Board in NPM.

- The harness and signal changes to adapt the signals from the OEM50 2 X 6 pattern to an OEM75 1 x 9 1.25mm pattern are the following.

Note: The additional P2 for HSI and SPI interfaces are 1 x 8 1.25mm pattern.

OEM50		SE32XX
P2 Connector		
Pin 1	Exc Supply	No signal on the SE32XX
Pin 2	Exc Return is not used	No signal on the SE32XX
Pin 3	Serial Transmit	Same as P301 pin 8 - UART Transmit
Pin 4	Serial Receive	Same as P301 pin 7 - UART Receive
Pin 5	Vdd Return	Same as P701 pin 2 - Battery Minus
Pin 6	Vdd +5VDC	Same as P701 pin 1 - Battery Positive and 5VDC is a good supply voltage

OEM50		SE32XX
P1 Connector		
Pin 1	Open Output	SE32XX does not have a similar signal
Pin 2	Ground	Same as P301 pin 2, signal Ground
Pin 3	Wiegand Data1	Wiegand data output is per the SIA AC-01 (1996.10) specification, except Voh is 3.3VDC max, and not 4.0 to 5.5 VDC OEM50 is inverted logic
Pin 4	Wiegand Data0	Wiegand data output is per the SIA AC-01 (1996.10) specification, except Voh is 3.3VDC max, and not 4.0 to 5.5 VDC OEM50 is inverted logic
Pin 5	Power On Reset	Same as P701 pin 3 /Reset function
Pin 6	Hold	Similar to P701 pin 4, however /Hold is low active

2.5.2   OEM75

The SE32XX module I/O is directly pin-for-pin compatible with the OEM75.

The OEM75 antennas are incompatible with the SE32XX module.

ULPM average current remains the same while peak current is higher for the SE32XX module.

2.5.3   eProx Lock Module

The eProx® Lock connector is the same as the SE32XX connector P701.

CAUTION: The connections between the SE32XX and the eProx Lock modules are reversed.

A straight-thru cable will not work. Twist the cable 180 degrees to ensure that Pin 1 on one module correctly mates with Pin 1 on the other module.

The two-wire 125 kHz antenna for the eProx Lock may not be interchangeable with an SE32XX Prox antenna.

3   Connector Configuration

3.1   SE3200Axx Connectors
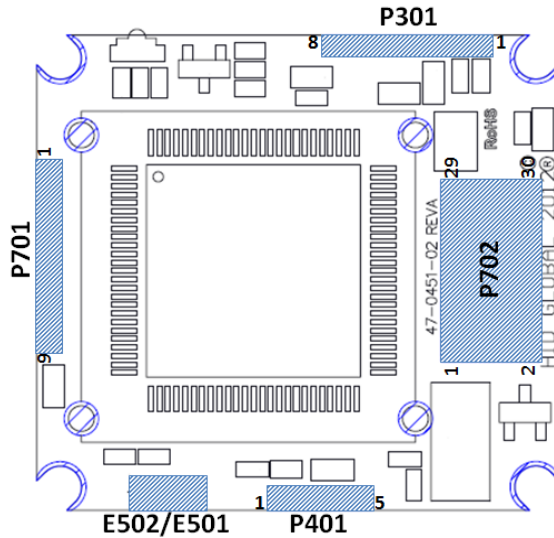
Figure 2: SE3200Axx Connector Configuration

3.2   SE3210Axx Connectors
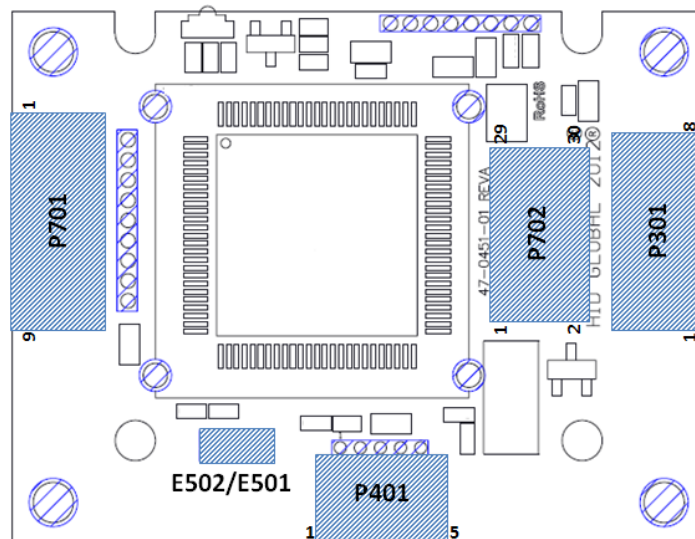
Figure 3: SE3210Axx Connector Configuration

3.3   Pin Configuration

3.3.1   P301 Host Interface Connector

This connector is compatible with P1 of the OEM75 module.

Table 2: P301 Pin Configuration

Pin	Signal Name	Type	Function
1	+3.3 VDC	Output	0.1W maximum power sourced output
2	GND	Reference	Logic level reference
3	SPI_CLK	Input	SPI clock signal
4	SPI_nCS	Input	SPI chip select (active low)
5	SPI_MOSI	Input	SPI data in
6	SPI_MISO	Output	SPI data out
7	URX	Input	UART data in
8	UTX	Output	UART data out

3.3.2   P701 Power and I/O Connector

This connector is compatible with P2 of the OEM75 module.

Table 3: P701 Pin Configuration

Pin	Signal Name	Type	Function
1	VIN	Supply	Supply Voltage Positive
2	VRTN	Supply	Supply Voltage Negative
3	nReset	Input	Reset (active low)
4	nHold	Input	Signal that holds off the presentation of the card data. When asserted, this line either buffers a card or disables a card read until released, as configured (active low)
5	nGLED_CPRES	Output	The signal on this pin reflects the recognition of a card near the antenna. The autonomous read and buffered data from the credential is output on the configured host interface.
6	WG_DATA0	Output	Wiegand Data 0
7	WG_DATA1	Output	Wiegand Data 1
8	nBEEPER	Output	Signal which enables off board signaling
9	nRLED	Output	Signal which can be used to enable an off board LED

3.3.3 P702 Board to Board Connector

This connector is an alternative interconnection method to P301 and P701.

Table 4: P702 Pin Configuration

Pin	Signal Name	Type	Function
1	nHold	Input	Signal that holds off the presentation of the card data. When asserted, this line either buffers a card or disables a card read until released, as configured (active low)
2	VIN	Supply	Supply Voltage Positive
3	NC		Not Connected
4	VIN	Supply	Supply Voltage Positive
5	NC		
6	VRTN	Supply	Supply Voltage Negative
7	URX	Input	UART data in
8	SPI_MISO	Output	SPI data out
9	UTX	Output	UART data out
10	SPI_MOSI	Input	SPI data in
11	WG_DATA1	Output	Wiegand Data 1
12	VRTN	Supply	Supply Voltage Negative
13	WG_DATA0	Output	Wiegand Data 0
14	DNC		Do Not Connect
15	DNC		Do Not Connect
16	DNC		Do Not Connect
17	DNC		Do Not Connect
18	nReset	Input	Reset (active low)
19	+3.3VDC	Output	0.1W maximum power sourced output
20	VRTN	Supply	Supply Voltage Negative
21	nGLED_CPRES	Output	The signal on this pin reflects the recognition of a card near the antenna. The autonomous read and buffered data from the credential is output on the configured host interface.
22	SPI_CLK	Input	SPI clock signal
23	nBeeper	Output	Signal which enables off board signaling
24	SPI_nCS	Input	SPI chip select (active low)
25	NC		Not Connected
26	VRTN	Supply	Supply Voltage Negative
27	DNC		Do Not Connect
28	nRLED	Output	Signal which can be used to enable an off board LED
29	DNC		Do Not Connect
30	NC		Not Connected

3.3.4 P401 HF Antenna Connector

This antenna connection IS NOT compatible with an OEM75 antenna.

Table 5: P401 Pin Configuration

Pin	Signal Name	Type	Function
1	ATX	Output	13.56 MHz antenna driving signal
2	GND	Reference	Antenna ground reference
3	PING_LVL	Input	Signals for low power card detection in ULPM
4	PING_SIG	Output	
5	PING_EN	Output	

3.3.5 E501/E502 Prox Antenna Connector

Table 6: E501/E502 Pin Configuration

Pin	Signal Name	Type	Function
E501	PROX_TX1	Output	125 kHz antenna driving signal
E502	PROX_TX2	Output	

4 Mechanical Specifications

The following section details the mechanical specifications for the iCLASS SE Reader Module and its connectors. Detailed drawings are also available at the iCLASS SE Reader Module micro-site.

4.1 SE3200Axx

This form factor is compatible with OEM75 model 3141ADx.
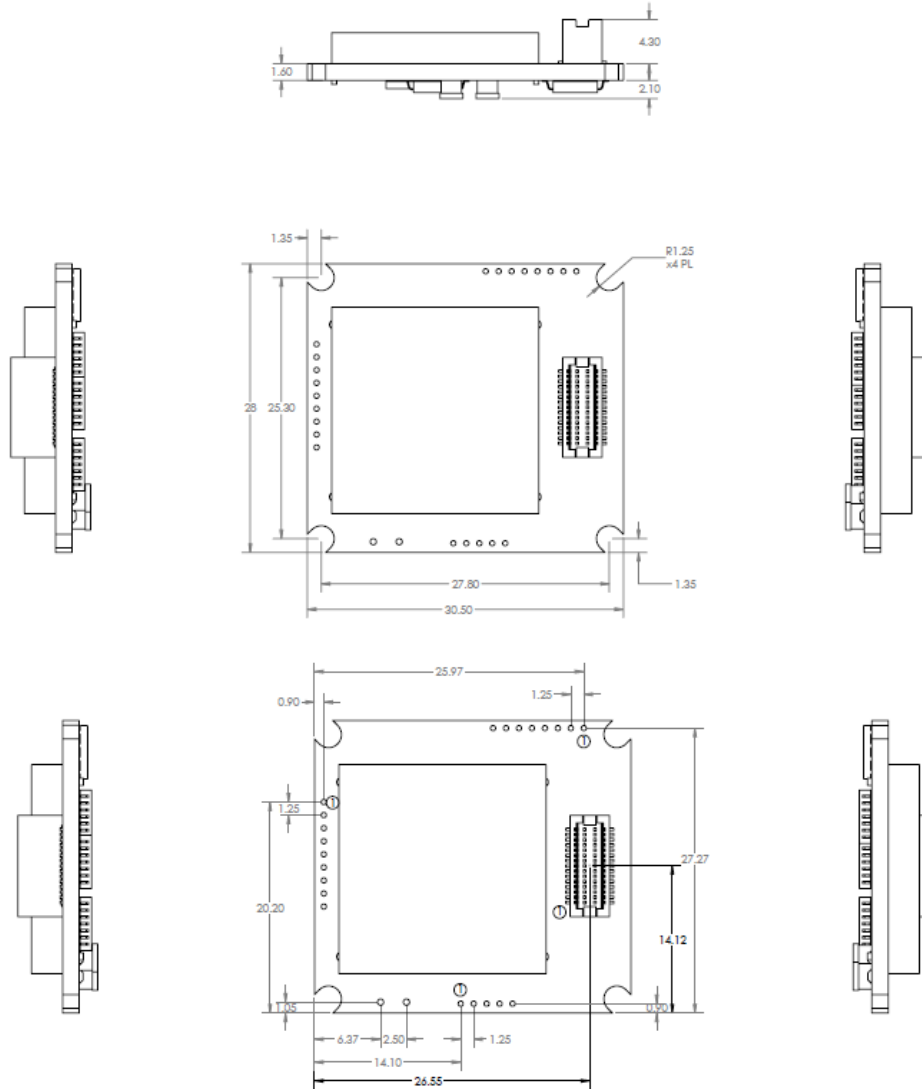
Figure 4: SE3200 Mechanical Drawing

4.2 SE3210Axx

This form factor is compatible with OEM75 modules 3141AAx, 3141AEx and 3141ACx.
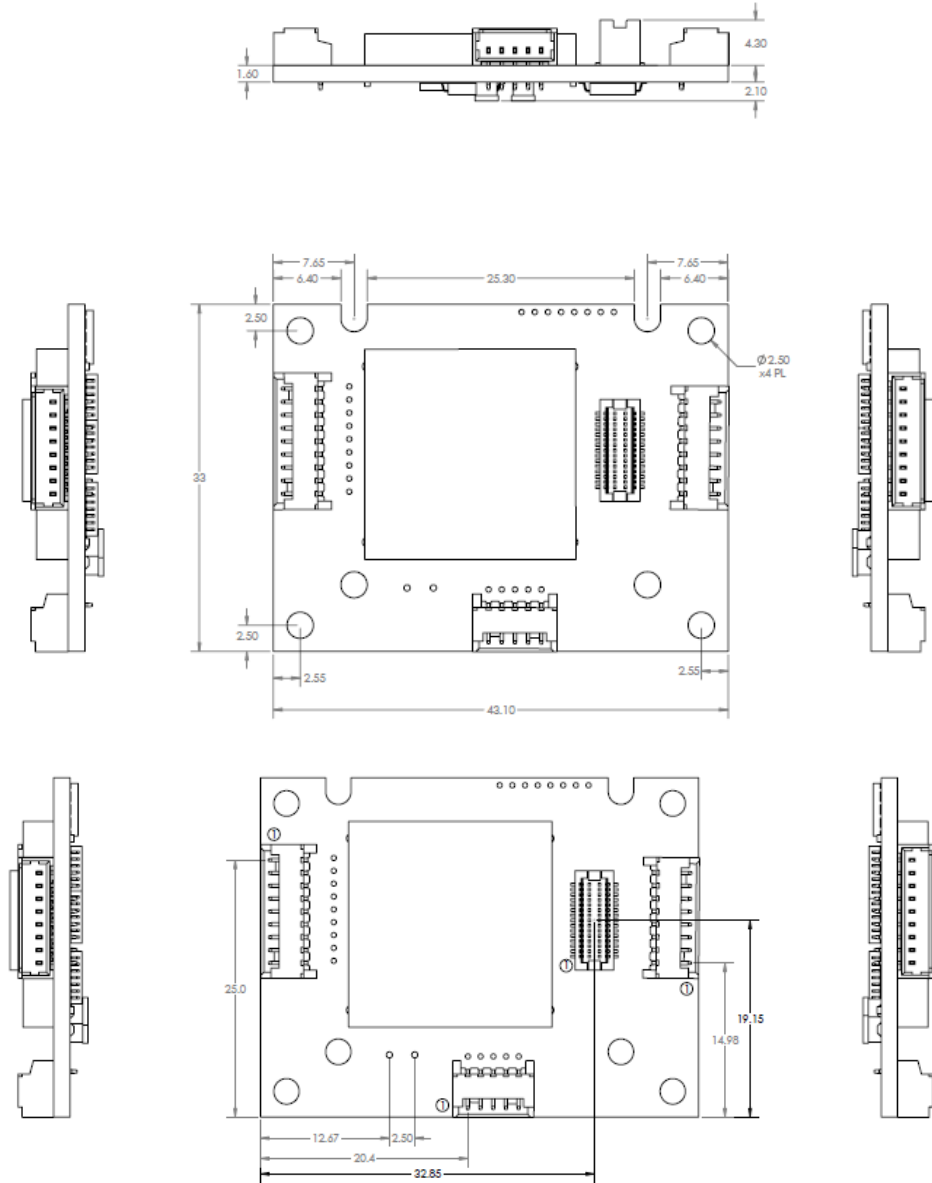
Figure 5: SE3210Axx Mechanical Drawing

4.3   Connector Types

4.3.1   SE3210Axx Connector Types

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

Table 7: SE3210 Connector Types

Connector	Function	Type / Counterpart	
P301	Power supply and host interfaces	Manufacturer: Type: Part Number: Mates with:	Molex PicoBlade 53048-0810 Molex 05102 series
P701	Wiegand and I/Os	Manufacturer: Type: Part Number: Mates with:	Molex PicoBlade 53048-0910 Molex 05102 series
P702	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-DS series
P401	HF Antenna	Manufacturer: Type: Part Number: Mates with:	Molex PicoBlade 53048-0510 Molex 05102 series
E501 / E502	Prox Antenna	Direct connect solder to module - no connector (It is recommended that the Prox antenna also be strain relieved by applying epoxy to adhere the antenna leads to the module for non potted integrations)	

4.3.2   SE3200Axx Interconnect

The SE3200Axx is designed as the smallest form factor possible. This module offering was designed to be header mounted on a host board utilizing the P301 and P701 through-hole connections. Use P702 as an alternative board-to-board connection if preferred.

Some header sources are:

- Cherng Weei
- HLCO

Each company's part drawings are located on the DTK micro-site.

5 Electrical Specifications

5.1 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.

Table 8: Maximum Ratings

Operating Temperature	-25°C to 65°C
Storage Temperature	-45°C to 85°C
Maximum Operating Voltage	10 VDC

5.2 Current Draw

The following measurements were performed with a 50 Ohm load connected to the HF interface. In the case a real antenna is connected to the iCLASS SE Reader Module's power, consumption changes depending on the presence of a transponder and its relative position to the antenna. For that reason, find guidance for changing power consumption for particular antennas in section 6 RF Interfaces.

The power consumption is independent of the supply voltage, as the iCLASS SE Reader Module uses a linear regulation system.

Table 9: Power Considerations

Mode	Parameter	Min	Typ	Max	Unit
Normal Power Mode Polling for HF transponders in autonomous mode [1] No Prox	Average DC current at 20°C		40		mA
	Peak Current [2] at 20°C		81		mA
Normal Power Mode Polling for Prox Credentials (HF deactivated)	Average DC current at 20°C		50		mA
	Peak Current [2] at 20°C		80		mA
Ultra Low Power Mode	Average DC current at 20°C		8.5		µA
	Peak Current [2] at 20°C		24		µA

[1] Polling cycle includes ISO/IEC14443 Type A and Pico15693. Adding additional protocols to the polling cycle may vary the power consumption.

[2] When the carrier is turned on, the current consumption of the module may build to create the required magnetic field. The peak currents are also considered in the average current measurement.

5.3   Power Supply

Table 10: Power Supply Electrical Characteristics

Signal	Parameter	Min	Typ	Max	Unit
VIN	Input Voltage SE32x0A0x	3.60	4.00	10.00	VDC
	Input Voltage SE32x0APx	4.95	5.25	10.00	VDC
	Current Consumption Normal Operation				mA
	Current Consumption Ultra Low Power Mode				µA

Note: The power consumption depends on the operation mode and the connected antenna / tuning. See section 4 Mechanical Specifications.

5.4   Host Interfaces

The host interface signals are backward compatible with the OEM75 product.

Table 11: Host Interface Electrical Characteristics

Signal	Parameter	Min	Typ	Max	Unit
SPI_nCS SPI_CLK, SPI_MOSI URX	Input Voltage	-0.5		7	VDC
	High-level Input Voltage	2.31			VDC
	Low-level Input Voltage			0.99	VDC
	Input Leakage Current		±0.1		µA
SPI_MISO UTX	High-level Output Voltage	2.9			VDC
	Low-level Output Voltage			0.4	VDC
	Output Current		2		mA
UART	Baudrate			576k	Baud
SPI	Baudrate			300k	Baud

5.5   Wiegand

The Wiegand interface signals are backward compatible with the OEM75 product.
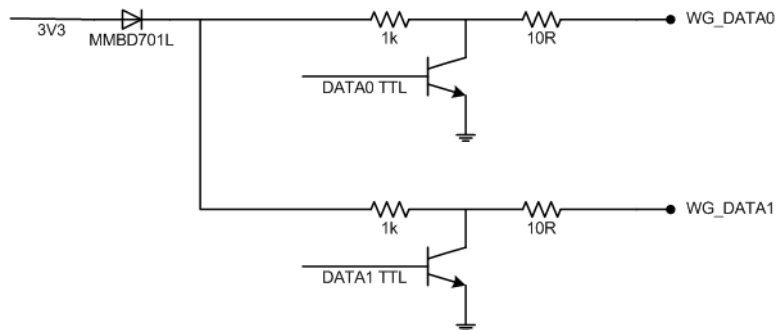
Figure 6: Output Circuit Wiegand Interface

Table 12: Wiegand Electrical Characteristics – Host Interface

Signal	Parameter	Min	Typ	Max	Unit
WG_DATA0 WG_DATA1	Current Draw (into 1K + 10ohms)			2.6(*)	mA
WG_DATA0 WG_DATA1	High Level Output Voltage		2.6		VDC

5.6 I/O

The I/O signals are backward compatible to the OEM75 product.

Table 13: I/O Electrical Characteristics – Host Interface

Signal	Parameter	Min	Typ	Max	Unit
nGLED_CPRES nBEEPER nRLED	Current Draw (Open Collector)			60	mA
nReset	Low-level Input Voltage			0.2	VDC
	High-level Input Voltage	1.6		5.5	VDC
nHold	Low-level Input Voltage			0.2	VDC
	High-level Input Voltage	1.6		5.5	VDC

5.7 Regulated Voltage Outputs

Table 14: Regulated Voltage Output Electrical Characteristics

Signal	Parameter	Min	Typ	Max	Unit
+3V3	Output Voltage	3.168	3.3	3.432	VDC
	Output Current			30	mA

Note: The regulated voltage output is deactivated if the module is in Ultra Low Power mode.

5.8 RF Interface (13.56 MHz)

Table 15: 13.56 MHz RF Interface - Electrical Characteristics Power Supply

Signal	Parameter	Min	Typ	Max	Unit
ATX	Output Power		750	1000	mW
PING_LVL PING_SIG PING_EN	Connect according to 6.1.1 Ultra Low Power Mode.				

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

5.9 RF Interface (125 kHz/Prox)

Table 16: 125 kHz RF Interface - Electrical Characteristics Power Supply

Signal	Parameter	Min	Typ	Max	Unit
PROX_TX1 PROX_TX2	Output Peak Current			200	mA

6 RF Interfaces

Depending on the configuration, the iCLASS SE Reader Module offers up to two different RF interfaces.

- HF interface for 13.56 MHz transponders
- Prox interface for 125 kHz transponders (SE32x0APx only)

6.1 HF Interface (13.56 MHz)

The HF interface is optimized for operation with 50Ω tuned antennas.
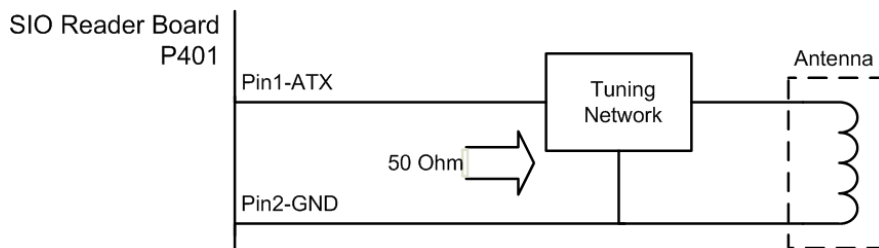
Figure 7: HF Interface

The impedance of 50Ω allows for integrated antennas, as well as remote antennas connected through a coax cable. Use a coaxial connection whenever operating the module in Normal Power Mode, if possible.
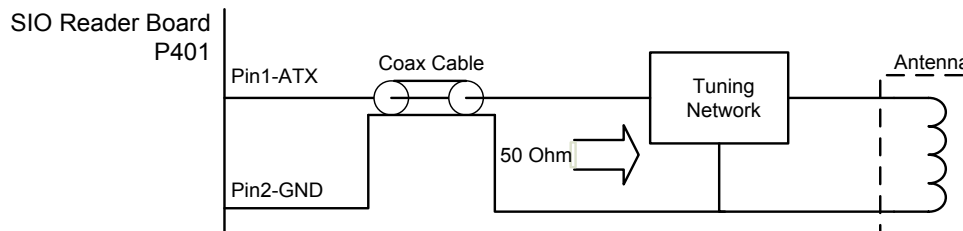
Figure 8: HF Interface with Coax Cable

Realize a simple tuning network by using two capacitors, one serial and one parallel.
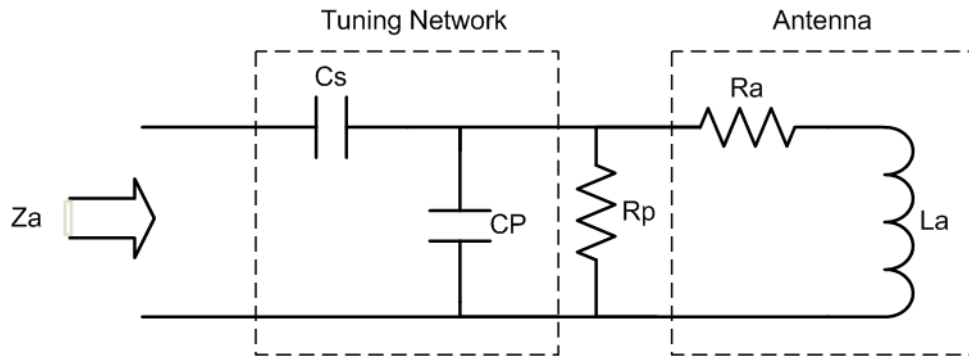
Figure 9: Basic Antenna Tuning Network

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 larger than 50 VDC are recommended.

In practice, Cs and Cp may consist of several parallel capacitors to get better granularity.

Be aware that HID is offering 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.

6.1.1 Ultra Low Power Mode

To allow for the ULPM, take additional measures at the antenna circuit. A transistor, as well as two additional measurement lines, is introduced to enable the low power card detection circuit on the iCLASS SE Reader Module.
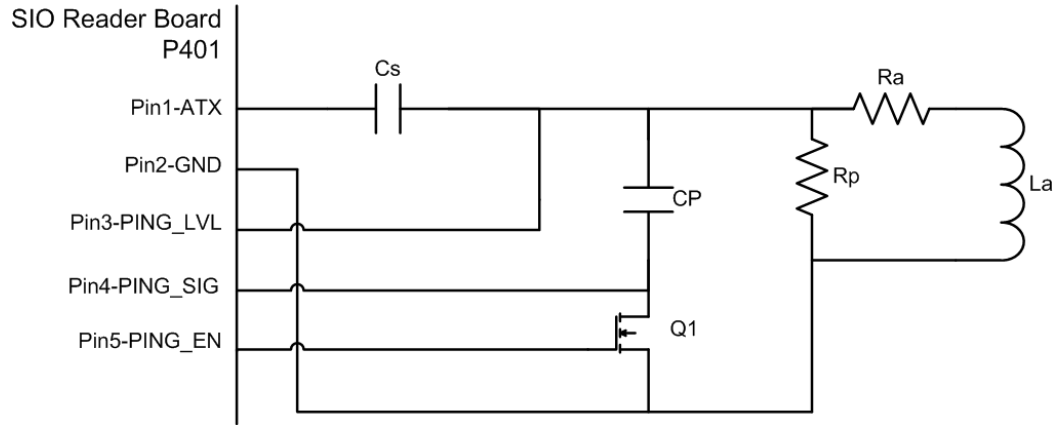
Figure 10: Tuning Network with ULPM Support

For Transistor Q1, a ZXM61N02F type or similar is recommended.

Note: Only the HF interface is capable of detecting transponders in ULPM. However, Prox transponders may be recognized by the HF interface. If supporting Prox credentials in the ULPM, concentrically rearrange the Prox and HF antenna.

6.2   Prox Interface (125 kHz; SE32x0APx only)

The Prox interface is optimized for connection to the HID Prox antenna 6500-101-03. If this antenna or one with equal electrical characteristics is used, no additional components are required.
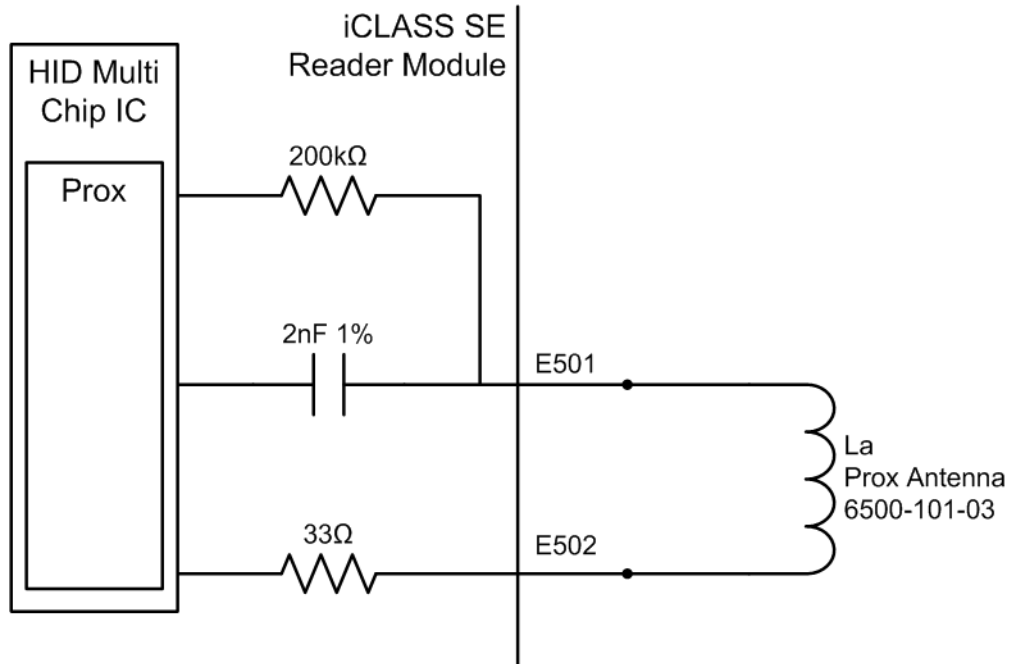
Figure 11: iCLASS SE Reader Module Prox Interface with Antenna

The onboard capacitor of 2nF and the external antenna coil build a serial resonator. Choose approximately 125 kHz for the resonance frequency. An additional 33Ω resistor is used to control the quality factor of the antenna.

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

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

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

7 Antennas

All antennas offered for the iCLASS SE Reader Module 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 and which might degrade its performance (for example, metal or stray capacitance).

When an air-tuned antenna is placed near metal, its tuning is affected causing a degradation of read performance.

All air-tuned antennas are optimized for a 50mm interconnect cable length. Different cable lengths may also lead to performance degradation and optimization may be required.

Environment deviations (from free air, as well as antenna interconnect cable length and routing the HF antenna interconnect cable along metal) require performing antenna optimization to ensure that the RF interface operates optimally within the integrated environment. It is suggested that the antenna and antenna interconnect cable be integrated into the end product to mirror a free air environment.

7.1 Basic Antenna Operation

Credentials obtain their power from the magnetic field generated by 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 when 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.

7.1.1 Inductive Coupling

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 power is supplied by the reader. To this end, the reader produces a magnetic field that the transponder uses for power.
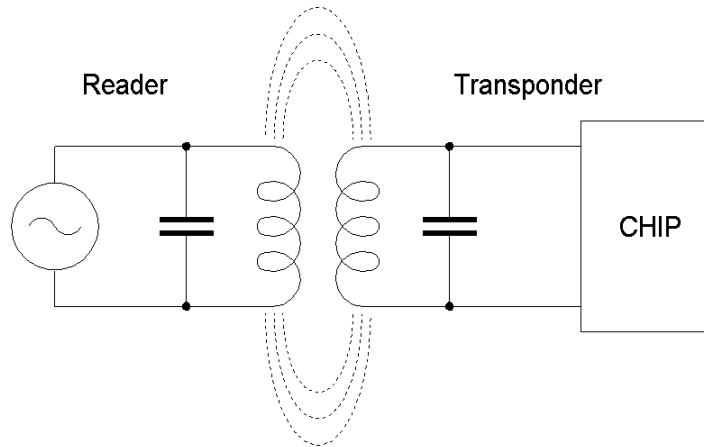
Figure 12: Inductive Coupling Principle

Mathematically, treat the coupling 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). 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.

Interpret the arrangement of the two coils as a loosely coupled transformer, with a coupling factor that varies with position and geometry.
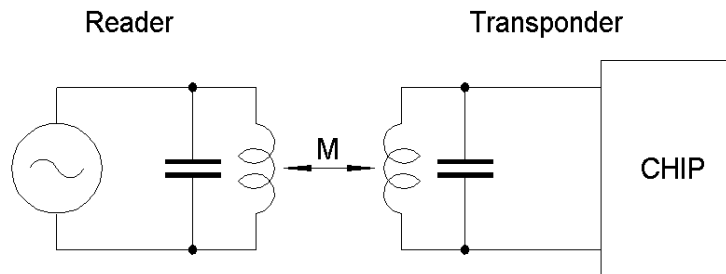
Figure 13: Mutual Inductance between Reader and Transponder Antenna

7.1.2 Load Modulation

As previously mentioned, interpret the inductively coupled system as a transformer. Putting a transponder (with a 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.
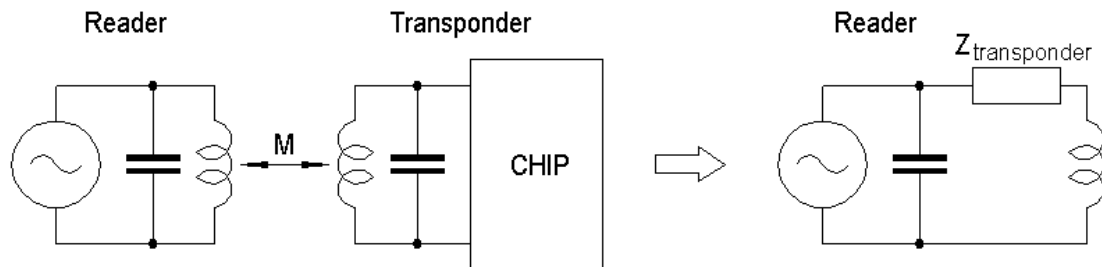
Figure 14: **Load Modulation Principle**

7.2 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.

7.2.1 Steps to Integration

Due to antenna parasitic shift and eddy current losses, RF implementation should be fully planned out prior to an industrial/mechanical design. This requires experimentation to be completed including the proximity of metal obstructions in the proximity of the antenna (including the LF antenna for HF+LF applications).

7.2.2 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.

7.2.3 Training and Assistance

HID Connect 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   4090A10 HF Antenna

Figure 15: 4090A10 HF Antenna

The 4090A10 HF antenna has an impedance of 50Ω and is optimized for operation with a 50mm ribbon cable. The antenna is tuned for a free air environment.

7.3.1   Mechanical Data

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

7.3.2 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. Table 17: 4090A10 HF Antenna with Standard ID1 Transponders shows tested card self-resonance frequency to provide an indication for the antenna design difference.

For these read range tests, the transponder serial number was read. No cryptographic operations were performed.

Table 17: 4090A10 HF Antenna with Standard ID1 Transponders Read Ranges

Transponder / IC Type	Manufacturer	Form Factor	Standard / Modulation Scheme	SRF [MHz]	Typical Read Range [mm]
MIFARE Ultralight (MF0ICU1)	NXP Semiconductors	ID1 Card	ISO/IEC14443 (Type A)	14.51	55
				14.64	50
				15.17	50
MIFARE Ultralight C (MF0ICU2)	NXP Semiconductors	ID1 Card	ISO/IEC14443 (Type A)	14.12	40
MIFARE Classic (MF1S50)	NXP Semiconductors	ID1 Card	ISO/IEC14443 (Type A)	14.04	55
				14.81	50
				15.83	40
MIFARE Classic (MF1S70)	NXP Semiconductors	ID1 Card	ISO/IEC14443 (Type A)	15.22	45
MIFARE Classic (SLE66CL160S)	Infineon Technologies	ID1 Card	ISO/IEC14443 (Type A)	15.28	50
				15.34	40
MIFARE Plus X (MF1PLUSx0)	NXP Semiconductors	ID1 Card	ISO/IEC14443 (Type A)	15.58	45
MIFARE DESFire (MF3ICD40)	NXP Semiconductors	ID1 Card	ISO/IEC14443 (Type A)	14.94	40
				15.37	45
				15.50	40
MIFARE DESFire EV1 (MF3ICD21)	NXP Semiconductors	ID1 Card	ISO/IEC14443 (Type A)	15.00	45
				15.73	40
SLE55R16	Infineon Technologies	ID1 Card	ISO/IEC14443 (Type A)	15.05	40
				15.68	35
SmartMX (P5CD072)	NXP Semiconductors	ID1 Card	ISO/IEC14443 (Type A)	16.07	40
				16.34	35
SmartMX (P5CD081)	NXP Semiconductors	ID1 Card	ISO/IEC14443 (Type A)	16.85	20
CD21 ITSO	Oberthur Card Systems	ID1 Card	ISO/IEC14443 (Type B)	15.21	20
				15.34	20
iCLASS 32k	HID Global	ID1 Card	ISO/IEC15693	13.63	100
				13.86	80
				14.14	70
iCLASS 16k	HID Global	ID1 Card	ISO/IEC15693	13.67	95

Transponder / IC Type	Manufacturer	Form Factor	Standard / Modulation Scheme	SRF [MHz]	Typical Read Range [mm]
iCLASS 2k	HID Global	ID1 Card	ISO/IEC15693	13.48	95
My-d vicinity plain (SRF55V02P)	Infineon Technologies	ID1 Card	ISO/IEC15693	13.93	90
My-d vicinity secure (SRF55V10S)	Infineon Technologies	ID1 Card	ISO/IEC15693	14.44	75
Tag-it HF-I Plus	Texas Instruments	ID1 Card	ISO/IEC15693	13.74	70
ICODE SLI (SL2ICS20)	NXP Semiconductors	ID1 Card	ISO/IEC15693	13.38	80
ICODE SLI-S (SL2ICS53)	NXP Semiconductors	ID1 Card	ISO/IEC15693	13.68	120
LRi2K	ST Microelectronics	ID1 Card	ISO/IEC15693	13.68	110
				13.89	90
FeliCa RC-S962	Sony Corporation	ID1 Card	FeliCa	13.52	65
				14.15	50
FeliCa RC-S915	Sony Corporation	ID1 Card	FeliCa	13.57	35
				13.58	35

7.3.3 Typical Read Ranges with HID Multi Technology Cards

For this read range tests the serial number of each individual HF chip inside the multi technology card was read. For Prox read ranges, see Section 7.4 6500-101-03 Prox Antenna.

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

Table 18: Typical Read Ranges 4090A10 HF Antenna - HID Multi Technology Cards

Card Type	Manufacturer	Standard / Modulation Scheme	Chip	Typical Read Range[mm]
MIFARE / Prox	HID Global	ISO/IEC14443 (Type A)	MIFARE	40
DESFire / Prox	HID Global	ISO/IEC14443 (Type A)	DESFire	35
iCLASS / MIFARE / Prox	HID Global	ISO/IEC14443 (Type A)	MIFARE	45
		ISO/IEC15693	iCLASS	60
iCLASS / DESFire / Prox	HID Global	ISO/IEC14443 (Type A)	DESFire	40
		ISO/IEC15693	iCLASS	50

7.3.4 ULPM Card Detection Range

The card detection range in Ultra Low Power Mode depends on the loading effect the transponder imposes on the iCLASS SE Reader Module'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 detection ranges with some transponders.

Table 19: ULPM Card Detection Ranges 4090A10 HF Antenna

Transponder / IC Type	Manufacturer	SRF[MHz]	Typical Detection Range[mm]
MIFARE Ultralight (MF0ICU1)	NXP Semiconductors	14.51	55
MIFARE Classic (MF1S50)	NXP Semiconductors	14.04	55
MIFARE DESFire (MF3ICD40)	NXP Semiconductors	15.37	45
iCLASS 32k	HID Global	13.63	90
FeliCa RC-S962	Sony Corporation	13.52	85

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.

7.3.5 RF Properties

Provided is an overview on the RF properties of the 4090A10 HF antenna in combination with the iCLASS SE Reader Module. The modulation waveforms were measured at a distance of 10mm. 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 to the ISO/IEC10373-6 standard.

Note: The following graph shows that at distances smaller than 12mm, the detuning of the Reference PICC used for the measurement causes the field strength to decrease. Observe similar behavior with transponders that introduce a loading effect of similar magnitude.

4090A10 Magnetic Field Strength H

Table 20: ISO/IEC14443 Type A Modulation Waveforms

	T1 Pause Length	2.52µs

	T2 Low Time	520ns
	T3 Rise Time to 90%	325ns
	T4 Rise Time to 60%	98ns
	Overshoot	8.53%

Table 21: ISO/IEC14443 Type B Modulation Waveforms
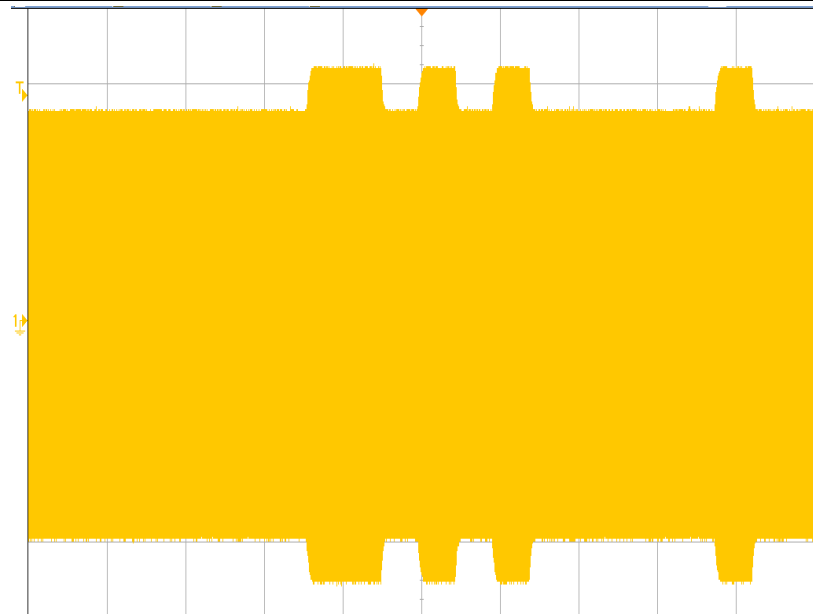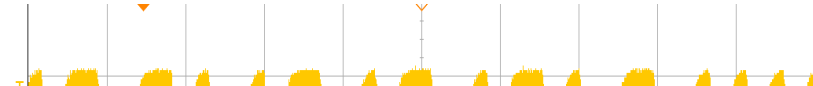
Tr Rise Time	720ns
Tf Fall Time	510ns
Modulation Index	10.13%
Overshoot	1.2%
Undershoot	0.9%

Table 22: FeliCa Waveforms

Tr Rise Time	730ns

	Tf Fall Time	610ns
	Modulation Index	12.50%
	Overshoot	0.2 %
	Undershoot	0.1%

7.3.6   Power Considerations

If a transponder is presented to the 4090A10 HF antenna, the impedance of the antenna is bound to change. The magnitude of the impedance change depends on various factors like

Geometrical relationship between the antennas (coupling)

Impedance/power consumption of transponder

…

This leads to a change in power consumption of the reader. The following table provides an overview on power consumptions recorded with different transponders.

Table 23: Power Considerations

Mode	Parameter	Min	Typ	Max	Unit
- iCLASS card in 10mm distance - Polling for HF transponders in autonomous mode*1 - No Prox	Average DC current at 20°C		120		mA
- iCLASS card in 50mm distance			90		mA
- iCLASS card in 70mm distance			45		mA

7.4   6500-101-03 Prox Antenna

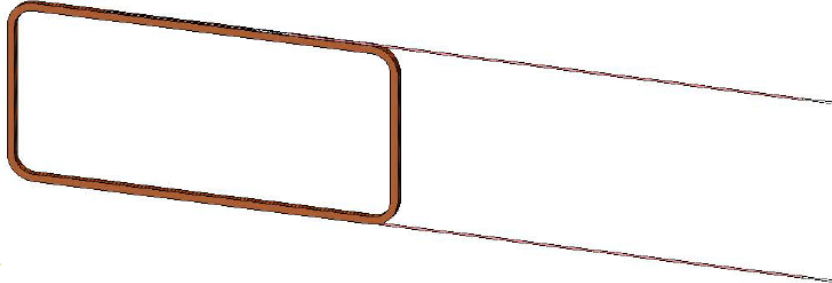The iCLASS SE Reader Module is optimized for operation with this Prox antenna. No external components are required.

Figure 16: 6500-101-03 Prox Antenna

7.4.1   Mechanical Data

Detailed drawings are available at the iCLASS SE Reader Module micro-site.

The antenna has two 76.2mm 28AWG mag wire leads for interconnection to the iCLASS SE Reader Module. For soldering, a strip end with 3.81mm is included.
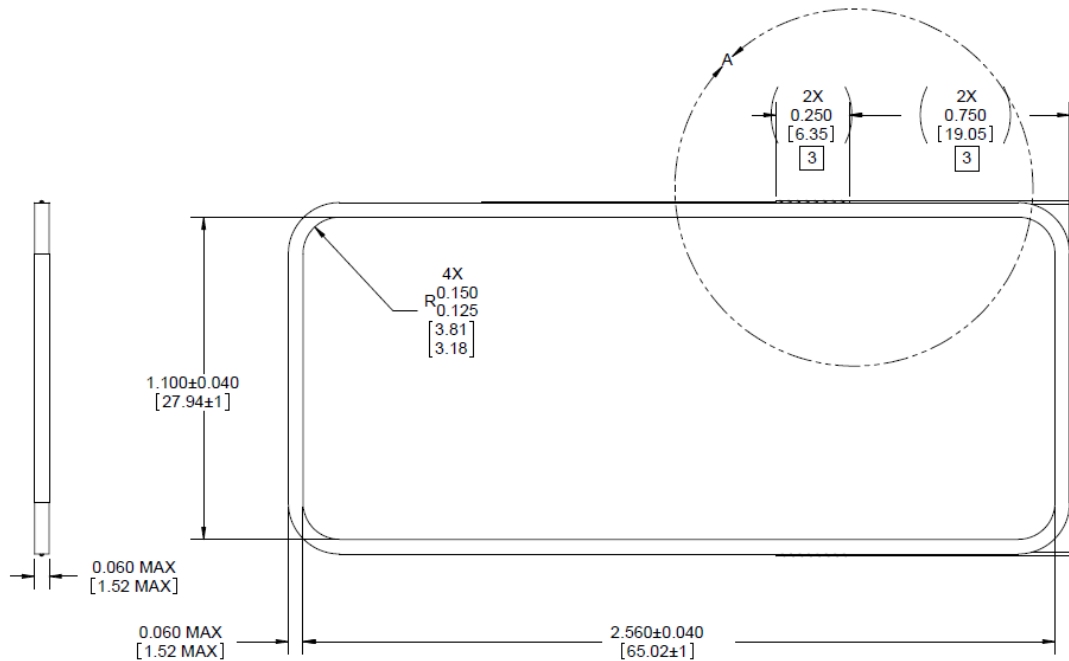

Figure 17: 6500-101-03 Mechanical Drawing

7.4.2   Electrical Characteristics

Table 24: Electrical Characteristics 6500-101-03

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

7.4.3 Typical Read Ranges

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

Table 25: Typical Read Ranges 6500-101-03 Prox Antenna

Transponder	Modulation Scheme	Typical Read Range [mm]
HID Prox	FSK	40
HID DuoProx II	FSK	60
MIFARE / HID Prox Combo Card	FSK	60
Indala Prox	PSK	55

8 Regulatory

8.1 RoHS

The SE32XX RoHS Declaration is located from the iCLASS SE Reader micro-site.

8.2 REACH

The SE32XX REACH Letter is located from the iCLASS SE Reader micro-site.

8.3 Safety

The following describes HID iCLASS SE Reader module 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

  Because HID OEM Modules are cRUus 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 SE32XX module.

- The iCLASS SE Reader module is intended to be part of a reader. The reader in which the iCLASS SE Reader module is used must translate the 3 VDC module Voh signalling to 4 to 5.5 VDC Voh SIA AC-01 (1996.10) signalling requirements.

The UL File for the iCLASS SE Reader Module is BP6568, Category Code ALVY2. View from the public UL Directory at http://database.ul.com/cgi-bin/XYV/template/LISEXT/1FRAME/index.htm.

8.4 Product Radio Certifications

The iCLASS SE Reader Module was tested under the FCC rules 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 module 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 un-intentional emissions testing will need to meet the FCC and IC requirements with the module installed into the final assembly or product. This also applies to CE Marking as defined by the R&TTE Directive.

- However, in many cases, the module may need to be retuned, due to the affects of the product enclosure and assemblies within this enclosure, and the de-tuning affect that this may have on the radio circuitry. In this case and if other radios exist, C2PC is required

- In the event that the HID OEM modules Kit is modified in any way, the radio transmitter operating at either 125 kHz or 13.56 MHz and the module 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.

FCC ID: JQ6-SE3200
IC ID: 2236B-SE3200

- 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 Marking. Standards: EN 300 330, EN 301 489-3, EN 50130-4, and IEC60950.

- A laboratory that is a 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.

Regulatory Compliance Assistance - HID Global provides technical assistance and laboratory recommendations, as required.

CAUTION: Any changes or modifications to this devise not explicitly approved by the manufacturer could void your authority to operate this equipment.

8.5   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.

8.6   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.

8.7   CE 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://certifications.hidglobal.com.

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