SpringCard Contactless Readers

Antenna Installation Guide

PMI9C2P-BA / January 2018

Agenda

- Introduction
- Inductive communication in a nutshell
- Electromagnetic environment – impact of a ferrite shield
- Installation DOs and DONTs

Inductive communication in a nutshell

Introduction

This document gives an overview on how a contactless reader, using the NFC / RFID @ 13.56MHz technology, communicates with a card and explains how to install the reader's antenna for an efficient operation.

This general guide applies to any contactless readers, but especially focuses on OEM modules. On these modules it is the integrator's responsibility to place the antenna in the final product, and to fit the contactless reader in the already size-constrained shell.

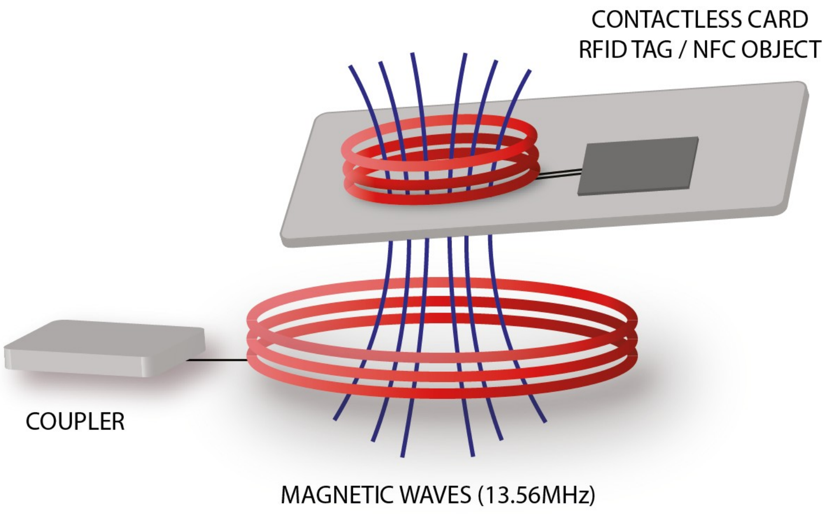
Technically speaking, the contactless ***reader*** *should be named a Proximity Coupling Device (PCD) or more simply a '*__*coupler*__*' if it operates according to the ISO/IEC 14443 standard, and a Vicinity Coupling Device (VCD) for the ISO/IEC 15693 standard. The* ***card*** *should be in turn named either a PICC (Proximity IC Cards) or a VICC (Vicinity IC Card), but it could also be a RFID* ***label****, an NFC* ***tag*** *, or even any NFC device running in card emulation mode.*

We will use indifferently either terms all along the document.

How the reader and the card communicate?

Even before discussing the ‘communication’ part, we must understand how the card is powered. A basic, standard, contactless card does not have any kind of battery. It is purely **remotly powered** by the reader.

Basically, the reader’s antenna is a coil (**inductance**) that emits an **alternating magnetic field** (at 13.56 MHz), exactly as the primary coil of an **electric transformer** would. The card’s antenna if the secondary coil of the transformer. The transformer transfers the energy from the reader (or coupler: PCD/VCD) to the card (PICC/VICC) and sustains a **bi-directional, half-duplex communication channel** between the two.



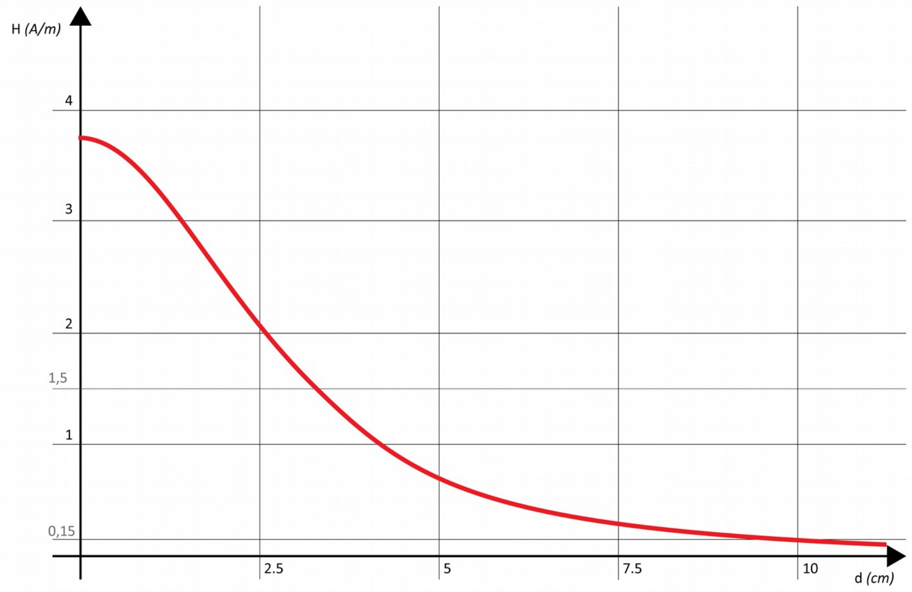
Decrease of the RF field with the distance

The RF field emitted by the reader decreases quickly with the distance.

The diagram on the right shows the level of the magnetic field (**H**, expressed in Ampere per meter) against the distance to the antenna, **along its axis**, for a typical 69x45 mm antenna driven by a SpringCard K663 or H663.

Out of the axis, the field decreases even quicker.

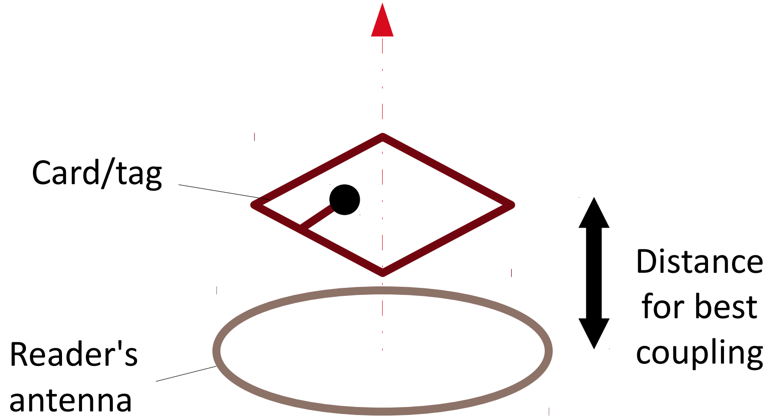
And since the card is powered by the RF field, when the card is too far, it does not even starts!

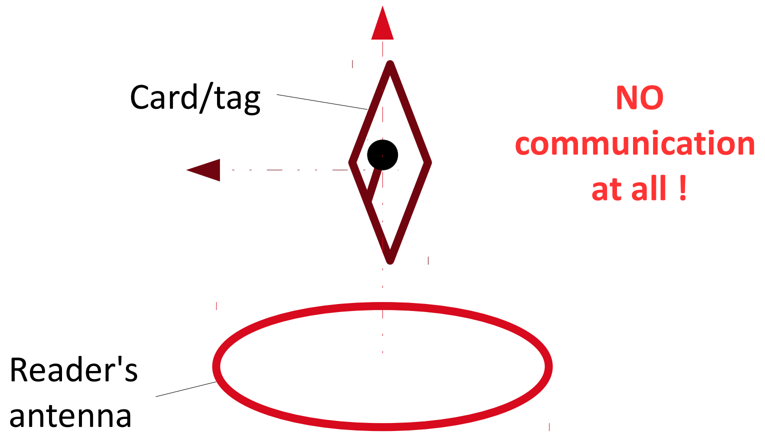


Reliability of the link *vs* card position and orientation

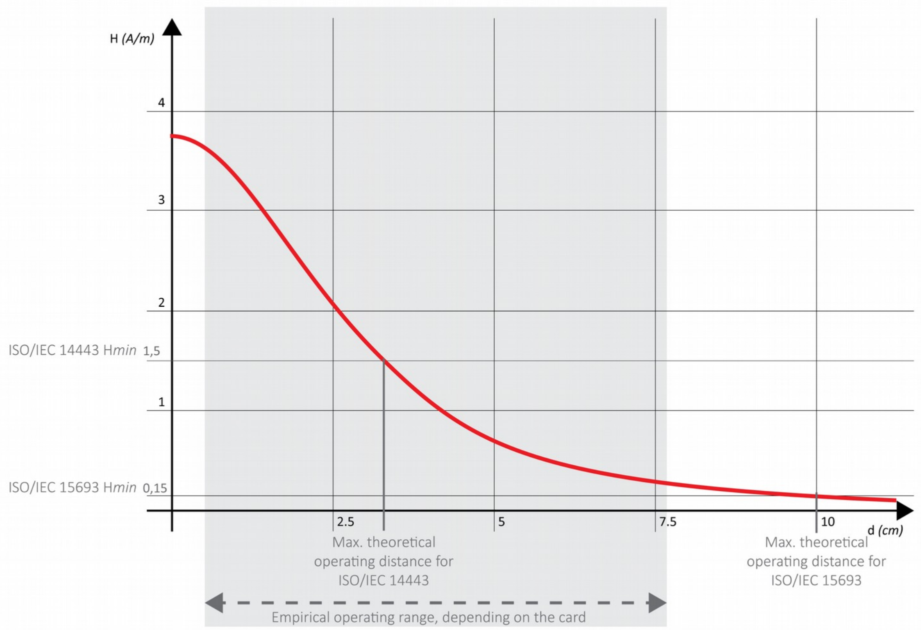
Once the card receives enough power to start, the quality of the communication channel depends totally **on the coupling factor of the transformer**. This coupling factor is at its highest when

1. both antennas (card & reader) have **approx. the same size** and are **designed to match** (correct tuning),
2. both antennas are placed in **parallel** planes, and share the **same central axis,**
3. the distance between both antenna is in the order of half their diagonal (or half their diameter).





Actual operating distance in free-field (1/2)



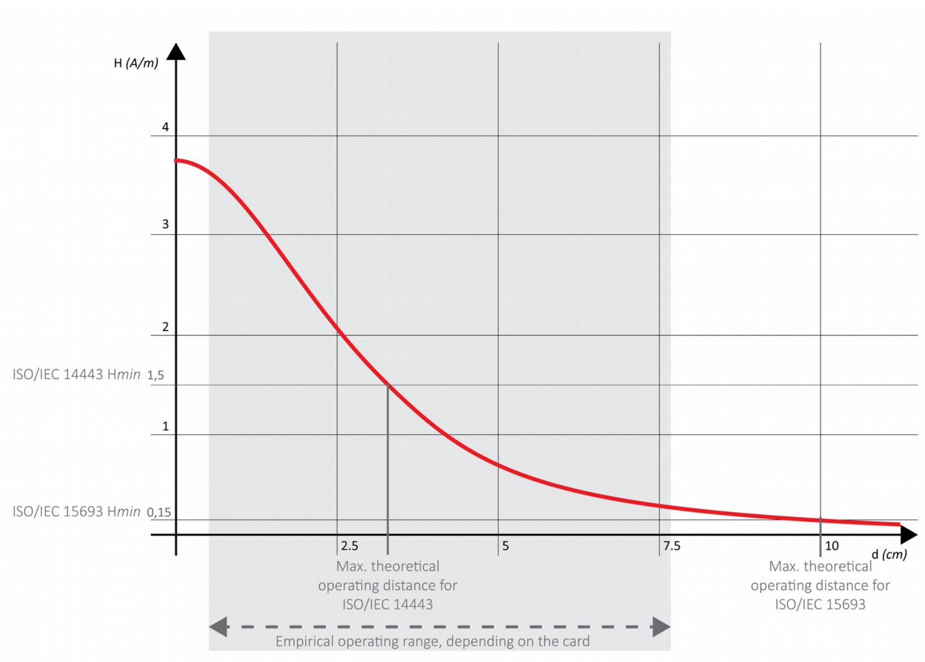
A card compliant with ISO/IEC 14443 must work until the field level fells under 1.5 A/m. Most cards will continue to work until 0.5 A/m or on even weaker fields. For ISO/IEC 15693, the minimum field level is 0.15 A/m.

With this knowledge of the card's internals, of the RF field level curve against the distance and the understanding of the coupling factor, we can estimate the operating range – or at least to explain the range that has been observed.

The grayed area in this diagram is the typical operating range of the 69x45 mm antenna with a Desfire PICC. The size of the card is ID-1 (class 1).

A smaller card would receive less power, would have a worse coupling with the reader, and will therefore not work so far from the antenna.

Actual operating distance in free-field (2/2)



Observe the small "hole" in the operating range, which means that the communication is being unreliable when the card is too close to the antenna.

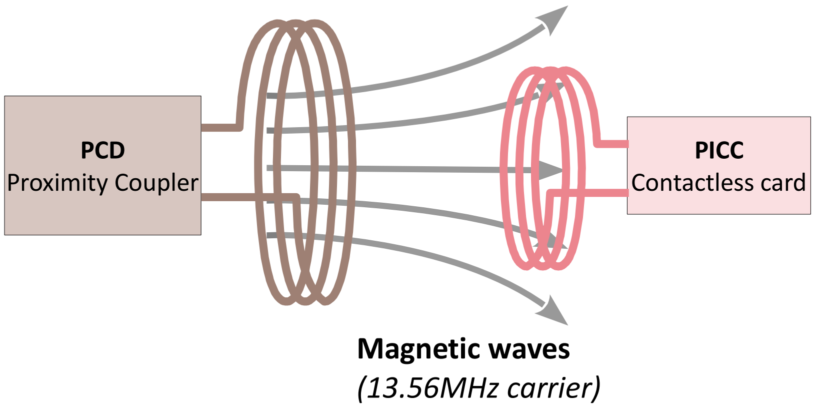
This hole is due both to the card's protection against the high voltages, and to a strong coupling factor that detunes heavily the reader's antenna.

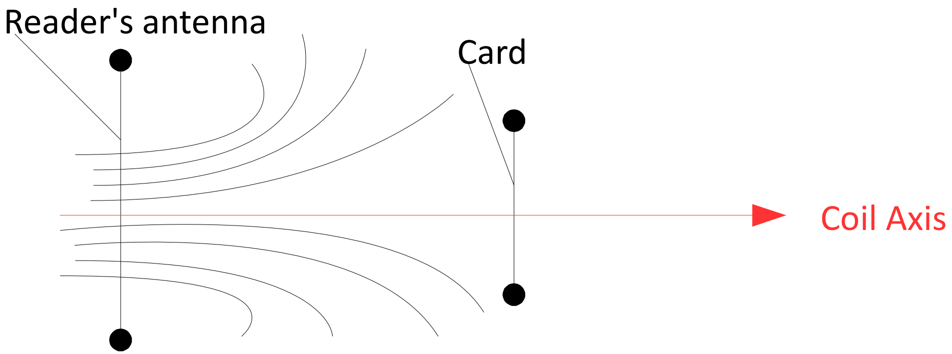
This could be surprising, when working with a bare antenna PCB, but this is not an issue since the size of this small "hole" is always shorter than the thickness of a typical product's shell.

In a nutshell: remain parallel, and respect the axis!

As a summary of these first slides, let's remember that:

1. the antenna of the card shall always be parallel to the reader's antenna
2. the best operating range is achieved when both antenna are on the same axis
3. the actual operating range depends on the relative size of the antennas, and on the intrinsic level of the reader's field.





Side view

Electromagnetic environment & impact of the ferrite shield

Constraints of the communication medium

The card is remotely powered by the reader, and the communicates with it, using **inductive coupling**, i.e. **magnetic waves**.

Magnetic waves are **not able to cross any conductive surface** (metal, metal-loaded plastics or paintings, PCD ground layers). For this reason, there shall be no conductive surface placed between the reader's antenna and the card.

Magnetic waves induce **eddy currents** (or **Foucault currents**) within conductors. When eddy currents appear, a large part of the reader's power is lost heating the conductor instead of powering the card. That's why there shall be no conductive material nearby the antenna.

The propagation of the magnetic waves is tied to the **magnetic permeability of the medium (µ)**. Most plastic materials, as well as dry air, have more or less the same permeability as the vacuum (μ_0) and allow the RF field to propagate well. On the other hand, glass, wet organic materials or any particular material with a magnetic permeability, should not be placed from the vaccum magnetic permeability ($\mu_R \neq 1$).

The Prox'N'Drive is a reader designed to be installed behind the wind-screen of a car.
It's antenna has a specific tuning, to take into account the magnetic permeability of the glass.

Ferrite (1/2)

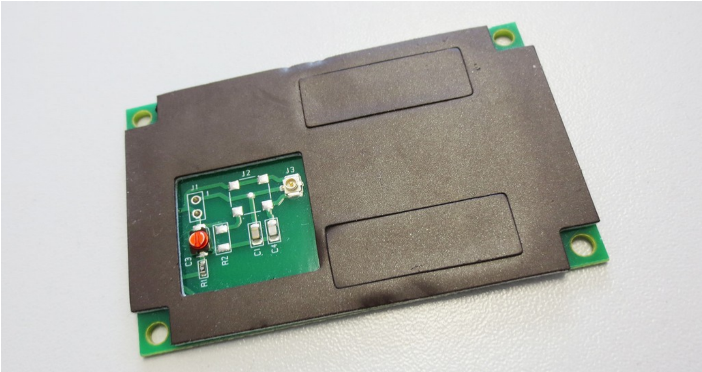
A ferrite is a type of ceramic compound that is both electrically non-conductive and ferrimagnetic. Its main effect is to "bend" the lines of a magnetic field.

SpringCard places a sheet of ferrite at the rear of most of its antenna.

This ferrite shield has two effects:

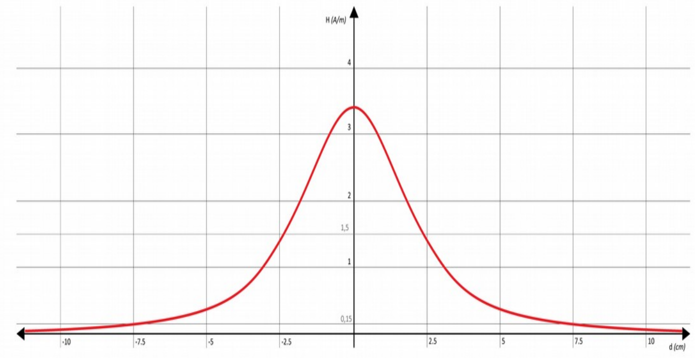
1. **Create a preferred face for the antenna.** A coil is perfectly symmetrical, and there is no technical reason to name a face 'front' and the other 'back'. Yet, by placing a ferrite shield on one face, the RF field is boosted on the other face, making it the preferred direction for operation. The front face is the opposite face to the ferrite shield.

2. Virtually **drive away** the antenna from its electromagnetic surrounding. Since the lines of the magnetic field are bent into the ferrite, there is less magnetic flow behind the antenna, which reduces the eddy currents in the nearby conductors.

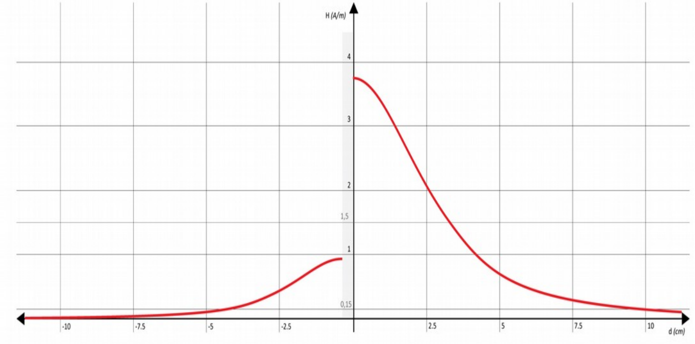


The ferrite sheet is the dark material at the back of the antenna’s PCB

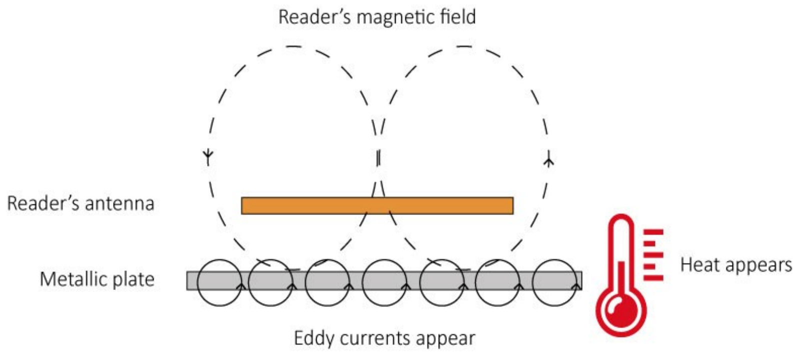
Ferrite (2/2)

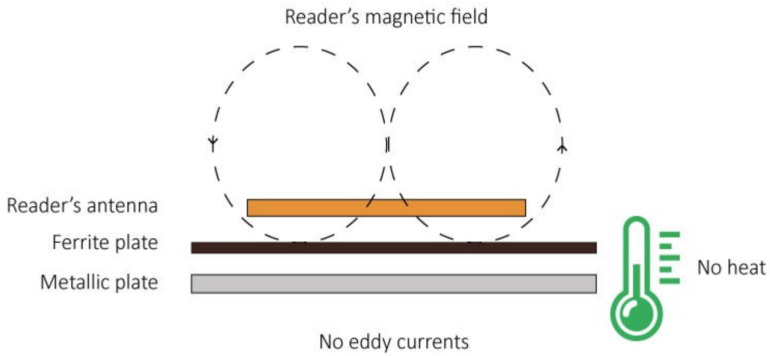


Magnetic field emitted by the antenna, **without** the ferrite shield at the back.



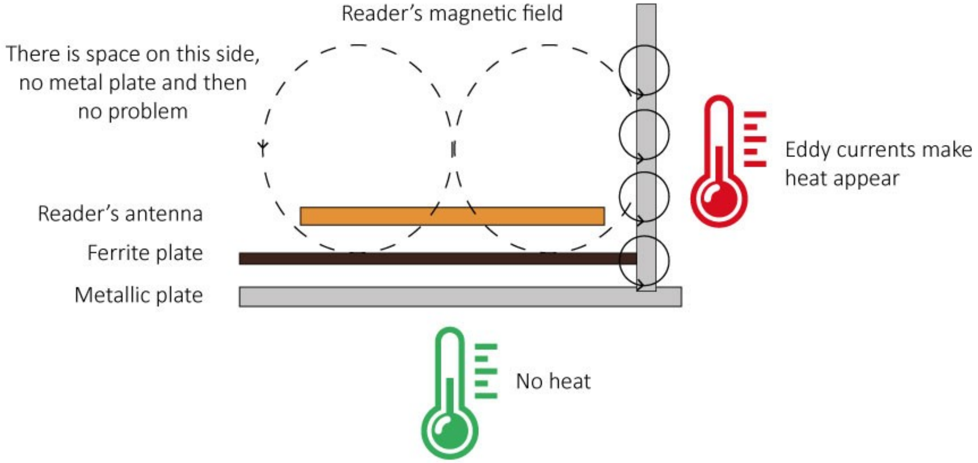
Magnetic field emitted by the antenna, **with** the ferrite shield at the back.





Mind the sides, too

The ferrite shield at the rear of the antenna helps lowering the losses due to eddy currents in the conductive materials located at the back of the antenna. But this does not solve anything for the conductive materials located at the sides of the antenna!

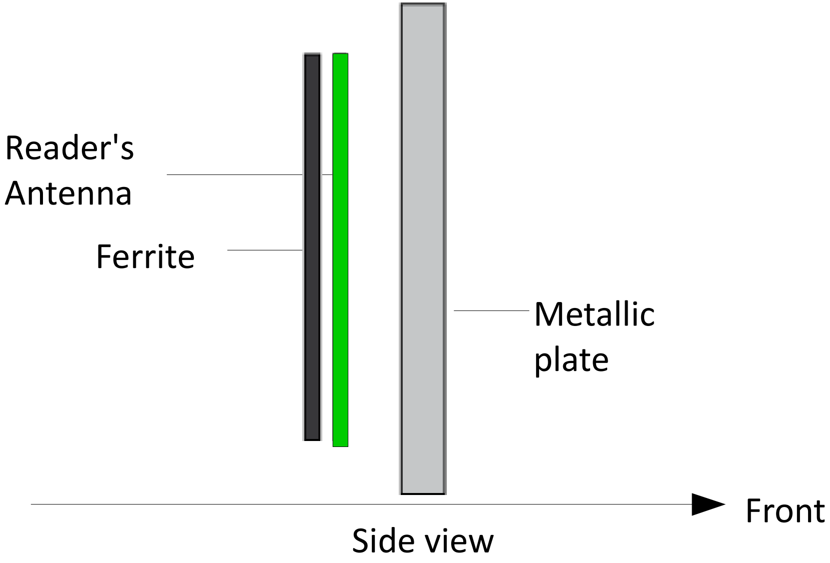


Installation DOs and DONTs

DOs and DON'Ts (1/4)

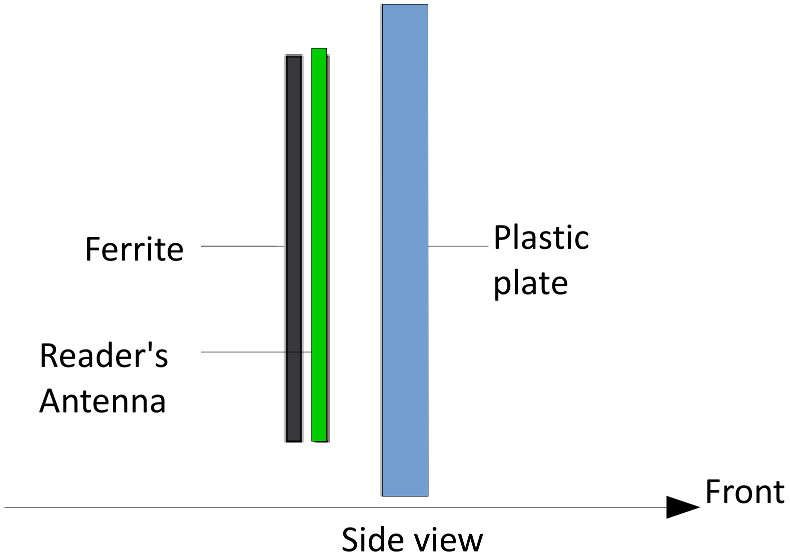
Metallic plate is in front of the antenna
and is too close to both ferrite & antenna

NO communication at all !



Plastic plate in front of the antenna, it has no impact on the antenna

Good communication !

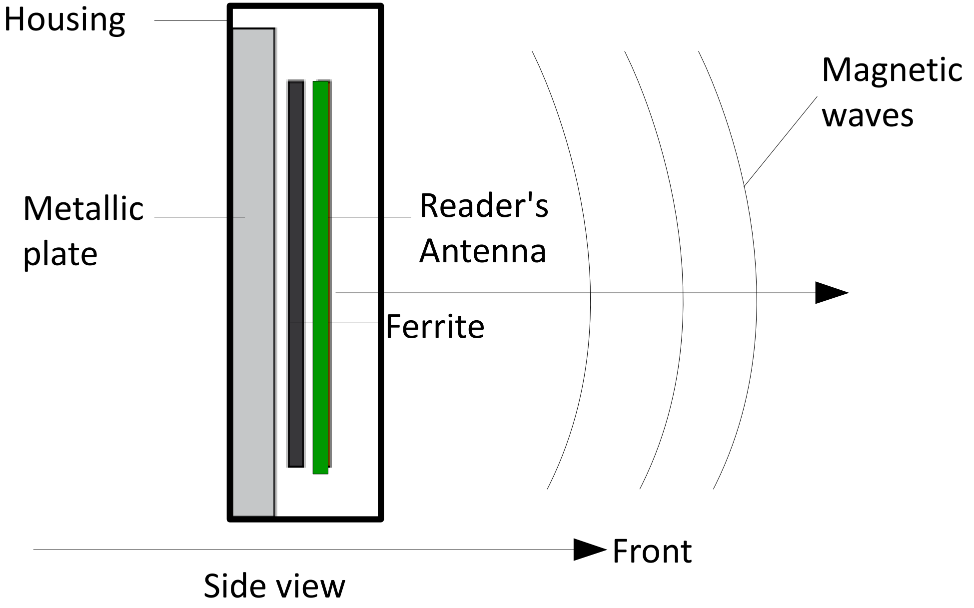


Note : The maximum operating distance between the reader's antenna and the card will be the shortest operating distance, called L.

DOs and DON'Ts (2/4)

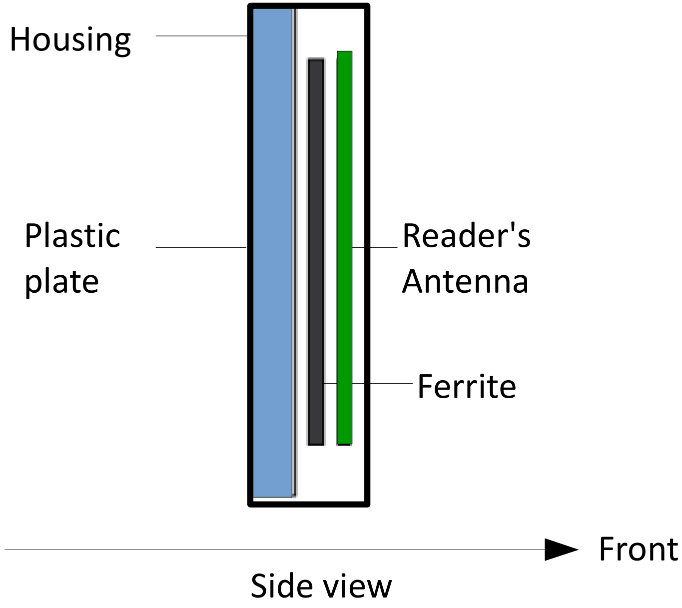
Metallic plate is behind the ferrite and is too close to both ferrite & antenna

No communication !



Plastic plate behind the ferrite and close to both ferrite & antenna

Good communication !



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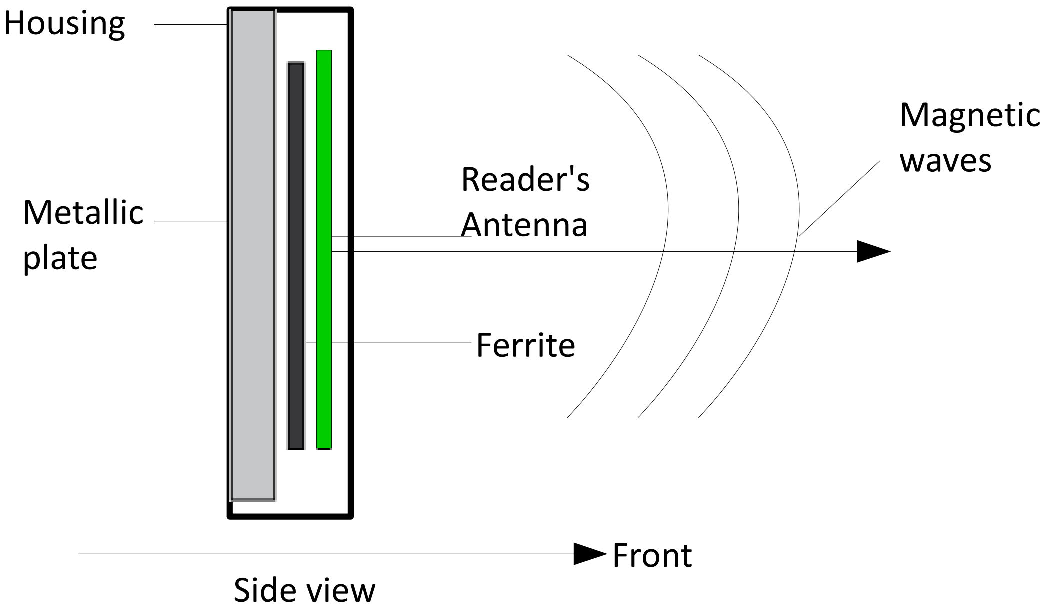
DOs and DON'Ts (3/4)

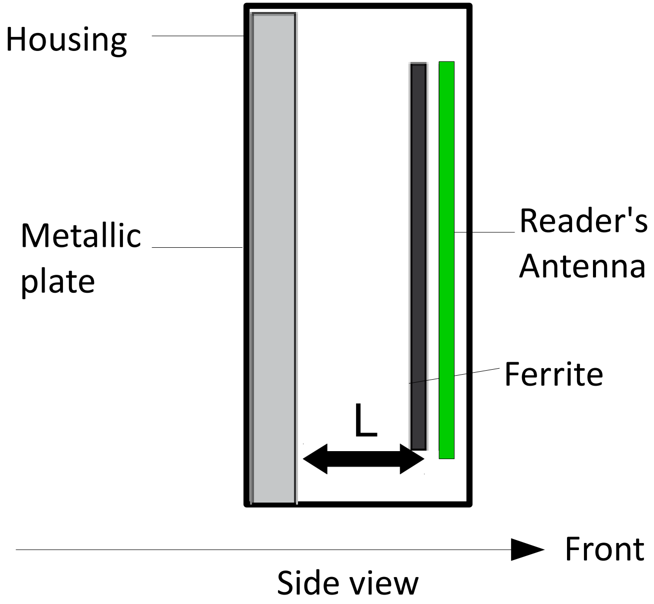
Metallic plate is behind the ferrite
and is too close to both ferrite & antenna

No communication !



Metallic plate is behind the ferrite and is distant enough
(L) from both ferrite and antenna.

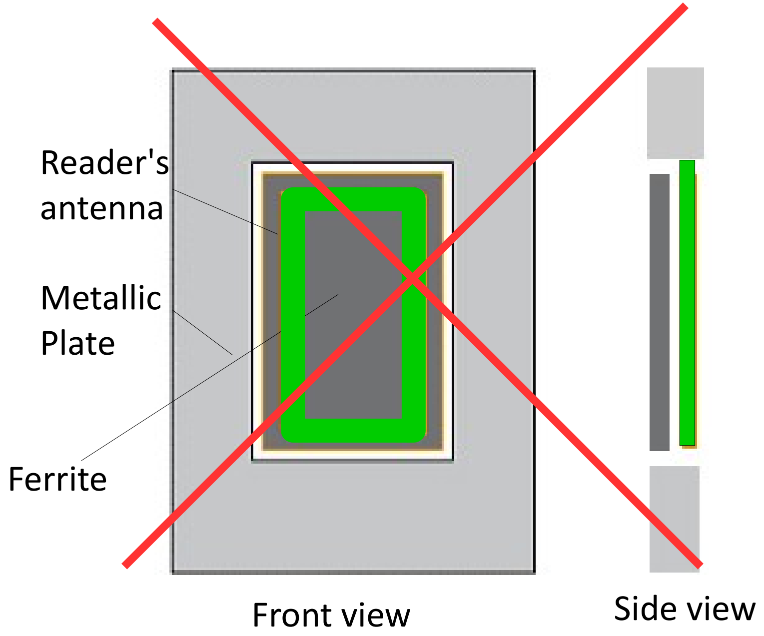
Good communication !



DOs and DON'Ts (4/4)

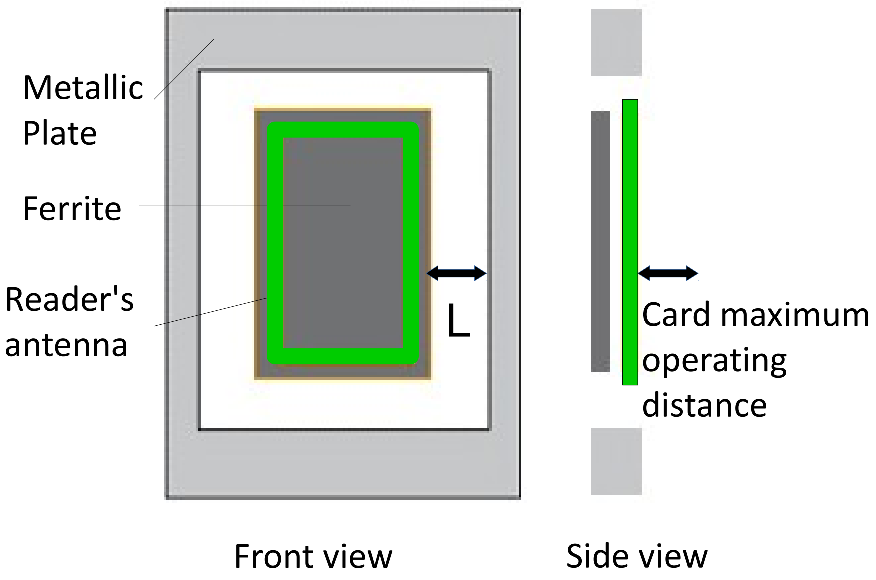
Both ferrite and antenna are positioned inside a rectangular hole of the metallic plate.

No communication !



Both ferrite and antenna are positioned inside a rectangular hole of metallic plate which is wide and high enough to not interfere with the magnetic field lines of the antenna.

Good communication !



Any questions ?

Please feel free to come back to us
if you need any additional information!

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SpringCard offers a wide range of products to meet
as many as possible of needs and use cases.
With a 18-year experience in contactless smartcards,
communication technologies and development on embedded or mobile systems,
SpringCard R&D Team is also a valuable partner to design your own solution or product.

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