AN10841

MIFARE Plus Card Coil Design

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Application note
COMPANY PUBLIC

Document information

Info	Content
Keywords	Contactless, MIFARE Plus, ISO/IEC 1443, Resonance, Coil, Inlay
Abstract	This document provides guidance for engineers designing magnetic loop antenna coils for the MIFARE Plus S, X and SE.

Revision history

Rev	Date	Description
1.1	20170404	Updated for 70 pF version
01	20090626	Initial version

Contact information

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1. Introduction

MIFARE Plus is a passive device (without battery) powered by a magnetic field generated by the PCD. To get the magnetic flux cut by the PICC, it requires a loop antenna.

This document describes some notes to the design of such loop antennas for MIFARE Plus. The detail design is explained in [1]. Although such antennas are relatively straightforward in principle and look very similar when comparing various contactless smartcards, experience proves that their parameters do have a noticeable impact on performance.

In this document, some examples are attached for your reference but please adapt and verify them before you go for production.

1.1 How to use this document

In this document, only the hints and notes specific to MIFARE Plus are explained. All the basics and common design details are explained in the base document [1]. Use the base document and apply wherever required the notes mentioned here.

1.2 Abbreviations and terms

Table 1 lists the abbreviations as used in this document.

Table 1. Table of abbreviations

Abbreviations	
PICC	Proximity Integrated Circuit Card (ISO/IEC14443), tag
PCD	Proximity Coupling Device (ISO14443), reader
f_{RT}	Threshold resonance frequency
Q	Quality factor

2. Card Coil Design notes for MIFARE Plus

There are different classes of antenna widely used in contactless application for MIFARE Plus PICC. For different antenna classes the design of PICC coils are different. Even different application requirements also lead to different antenna design. Basically, three parameters are important for card coil design: coil area, resonance frequency and quality factor.

2.1 Different classes of antenna according to ISO/IEC 14443-1

In the following figure Fig 1, different antenna sizes according ISO/IEC 14443-1 are shown.

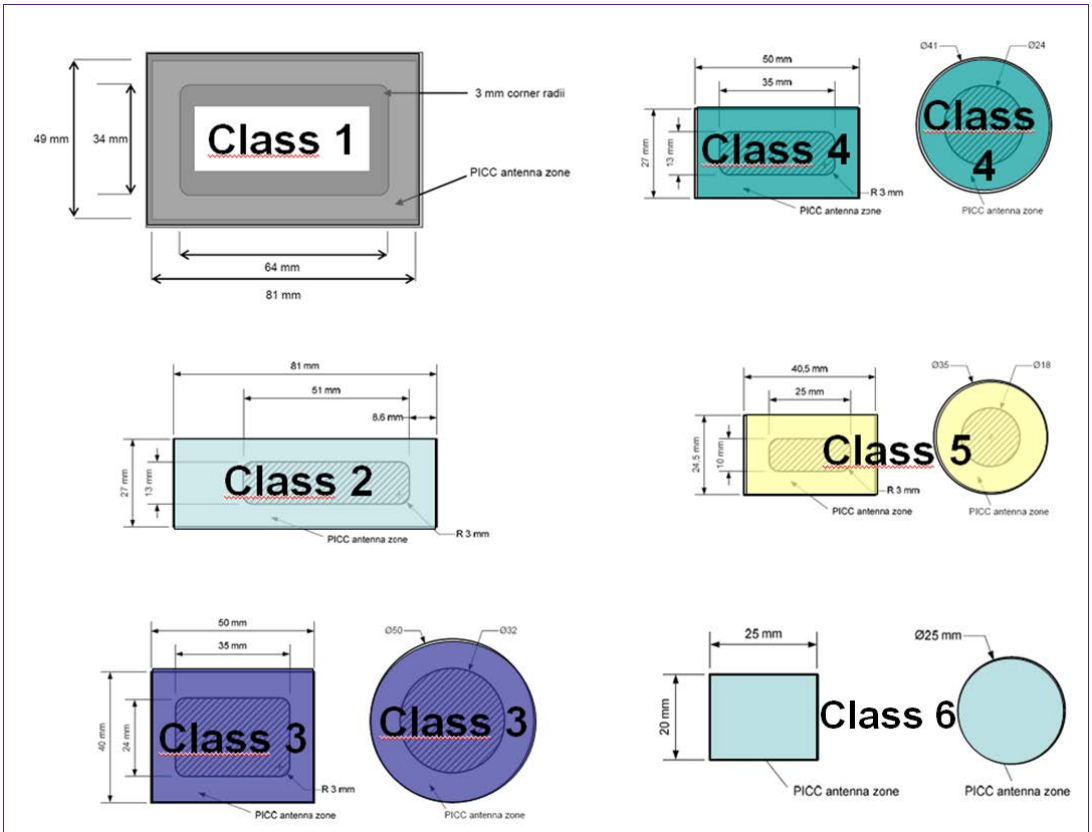

Fig 1. Different PICC antenna sizes

2.2 Average card coil area

Make a card coil area as big as possible. The bending corners are better than sharp corners.

2.3 Unloaded threshold resonance frequency

The appropriate resonance frequency of the antenna coil depends on the card ICs and applications. To cover manufacturing tolerances and optimum performance, for MIFARE Plus, the recommended threshold resonance frequency is given in Table 2.

2.3.1 Measurement of threshold resonance frequency

There are different ways to measure the resonance frequency, and may end up with different results. Follow the way described in the Card Coil Design Guide.

2.4 Unloaded Q of the coil

The quality factor of the antenna coil is very important for longer distance and stable communication. The appropriate Q of an antenna coil depends on the card ICs and applications. To cover manufacturing tolerances and optimum performance, for MIFARE Plus, the recommended Q is given in Table 2.

2.4.1 Measurement of unloaded Q of the coil

There are different ways to measure the Q, and may end up with different results. Follow the way described in the Card Coil Design Guide [1].

2.5 NXP recommendation for PICC coil design

Table 2 summarizes recommendations on MIFARTE Plus chip capacitance, inlay threshold resonance frequency a well as on quality factor of the coil for different classes (sizes).

Table 2. PICC coil design recommendation

Antenna class	Recommended chip of MIFARE Plus	Recommended threshold resonance frequency (f_{RT})	Recommended unloaded Q	Comments
Class 1	17pF	13.56 MHz < f_{RT} < 16.00 MHz	>30	For the single card application, a lower frequency is better and for multi-card (or stacked cards) applications, a higher frequency is better.
Class 2	70pF	12.70 MHz < f_{RT} < 14.50 MHz	>40	For 106 kbps and single card application. The optimum resonance frequency is 13.56 MHz.
Class 3	70pF	12.70 MHz < f_{RT} < 14.50 MHz	>40	For 106 kbps and single card application. The optimum resonance frequency is 13.56 MHz.
Class 4	70pF	12.70 MHz < f_{RT} < 14.50 MHz	>40	For 106 kbps and single card application. The optimum resonance frequency is 13.56 MHz.
Class 5	70pF	12.70 MHz < f_{RT} < 14.50 MHz	>40	For 106 kbps and single card application. The optimum resonance frequency is 13.56 MHz.
Class 6	70pF	13.00 MHz < f_{RT} < 14.00 MHz	>40	For 106 kbps and single card application. The optimum resonance frequency is 13.56 MHz.

NOTE: Increasing the communication bit rates may reduce the communication distance specially for the small classes of antenna (other than class 1).

2.6 Practical design hints and recommendations

2.6.1 ID1-sized antennas

Within the confines of the application and the card manufacturing processes used, try to maximize the antenna size. The outermost turn of the antenna coil should be placed as close as possible to the edge of the card (represented by an 81 x 49 mm rectangle, Fig 2).

Note: international standards and industry specifications may restrict the choice.

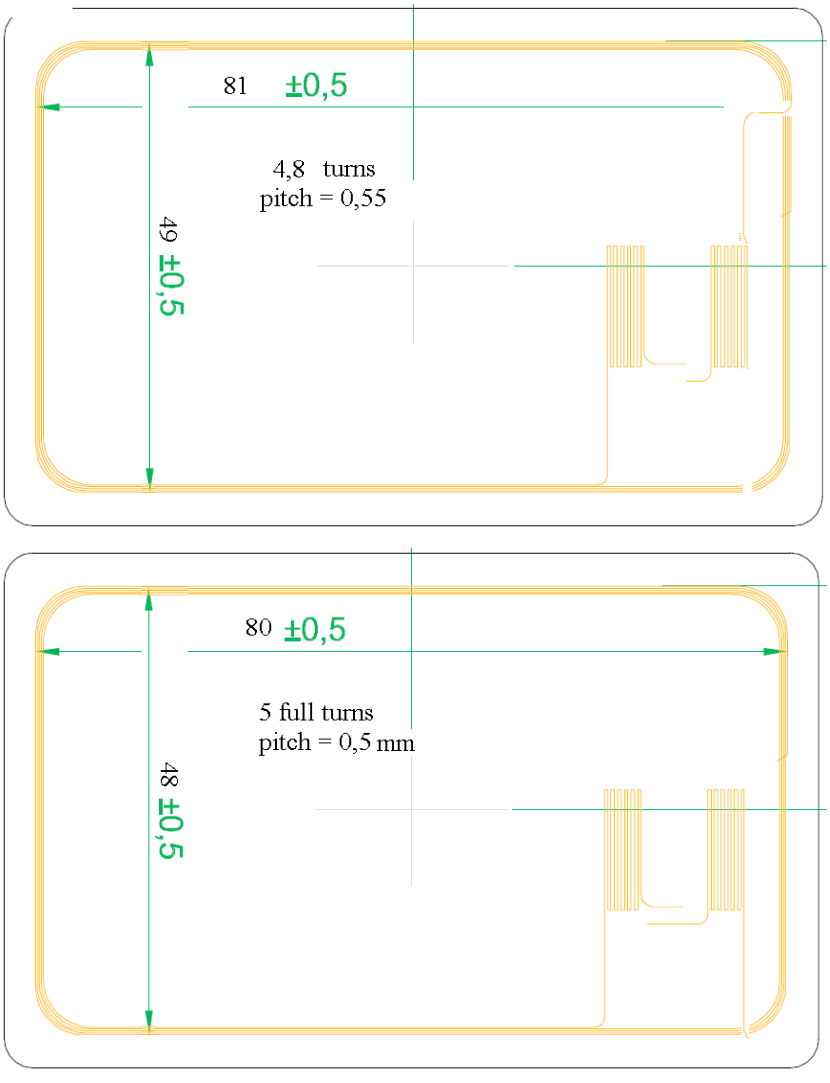

Fig 2. Class 1 antenna examples (with two different parameters)

For 17pF chip the ID1 size (class 1) antenna is recommended. For other classes use the 70pF version of MIFARE Plus chip.

Fig 3 shows further examples of typical parameters for different ID1-sized antenna designs. Besides geometrical coil parameters (orange colored area), also measured (blue colored area) and calculated (green colored area) electrical parameters are listed in comparison.

	Embedded Wire rectangular Antennas								
Dimensions	outline	mm	72,6 x 42		80,2 x 48	80 x 47,5	80 x 48	80,5 x 48	
	wire diam.	mm	0,112		0,112	0,112	0,112	0,112 ?	
	wire pitch	mm	0,14		0,45	0,45	0,45	0,3	
	turns		5		5	4,9	5	5	
measured	Ls @ 1MHz	µH	4,83		4,89	4,69	4,90	5,23	
	Rs Q 1 MHz	Ohm	2,05		2,29	2,22	2,24	2,37	
	fres	MHz	36,84		38,45	42,58	39,46	39,19	
	Rp @ fres	kOhm	55,00		69,00	90,00	90,00	55,00	
Calculated	Q @ fres		63,00		66,00	72,00	70,00		
	Cp	pF	3,87		3,51	2,98	3,32	3,16	
	Rs	Ohm	3,92		3,78	3,22	3,38	4,49	
	Q		105,03		110,11	124,00	123,70	99,16	

Fig 3. Typical parameters of different class 1 card antennas

2.7 Practical design hints and recommendations for 70pF IC

For class 2 and up to class 6 antennas, it is recommended to use 70pF chip version.

2.7.1 ID ½ sized (class 2) antenna

Geometrical parameters of one possible class 2 size antenna design, as well as its location within the ID1 card area is shown in Fig 4.

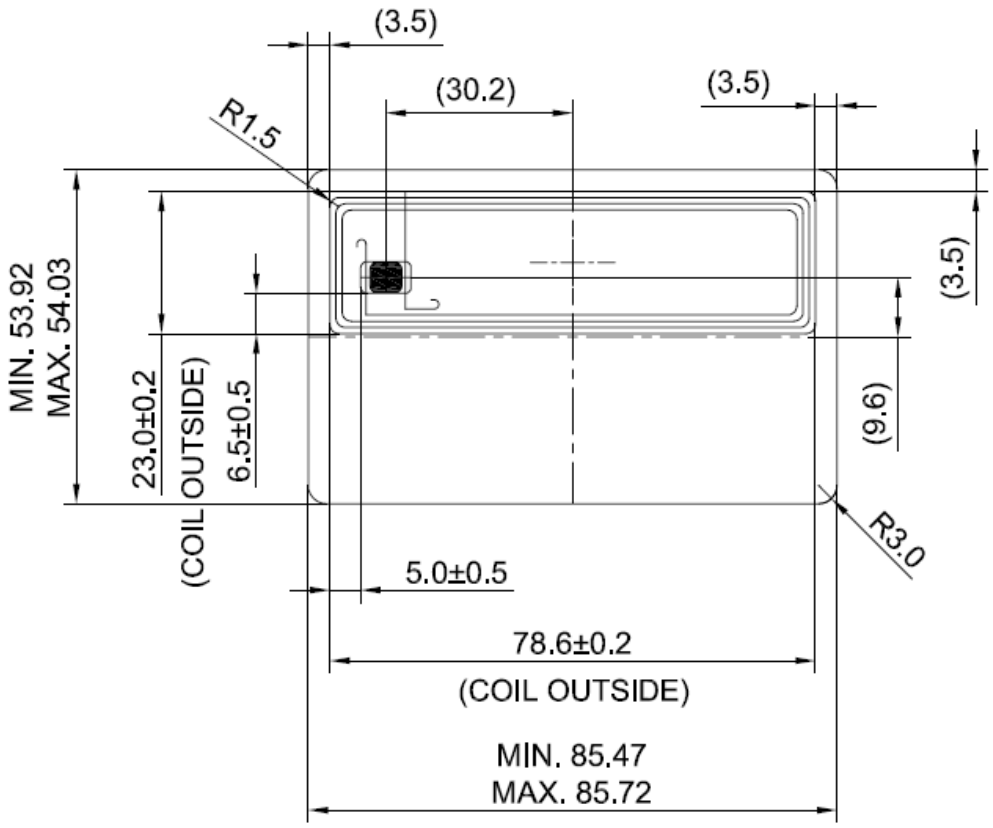

Fig 4. Class 2 Antenna example

3. Reference

[1] AN011732 “MIFARE Card Coil Design Guide”

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