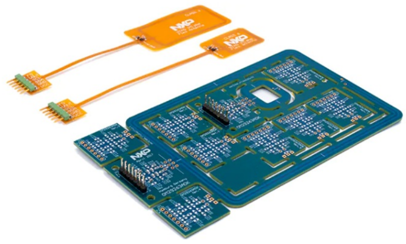

NXP UM11232 NFC Antenna Design Tool User Manual

UM11232
NFC Antenna Design Tool User Manual
Rev. 2 — 8 February 2024
User manual

Contents

Document information

Information	Content
Keywords	NFC Antenna Design, NFC Reader IC, Antenna Matching, NFC Antenna Design Tool
Abstract	This document describes the usage of the NFC Antenna Design Tool that can extend or even replace the Excel file mentioned in the different application notes about the NFC antenna design.

Introduction

The NFC Antenna Design tool supports the antenna coil synthesis based on some basic input parameters and calculates the matching circuit for:

- NXP NFC Reader ICs: PN7462/PN7362/PN7360, PN5180, PN5190, CLRC663/MFRC630/SLRC610, CLRC663 plus, PN7120, PN7150, PN7160, PN7642 and PN7220.
- NXP NFC Tag ICs: NTAG I2C Plus, NTAG213F, SLIX 2, NTAG 5 Link and NTAG 5 Boost.

Check the details of the antenna design in each IC application note for specific considerations. Refer to Section 4 for references.
The scope of the document is limited to the tool usage and does not cover NFC antenna design. For information on NFC antenna design, refer to Section 4.

Application overview

The tool consists of three parts:

- Dielectric and Reader/Tag selector
- Antenna geometry and calculation
- Reader/Tag tuning calculation

Figure 1 shows the NFC Reader Antenna and tuning calculation part.

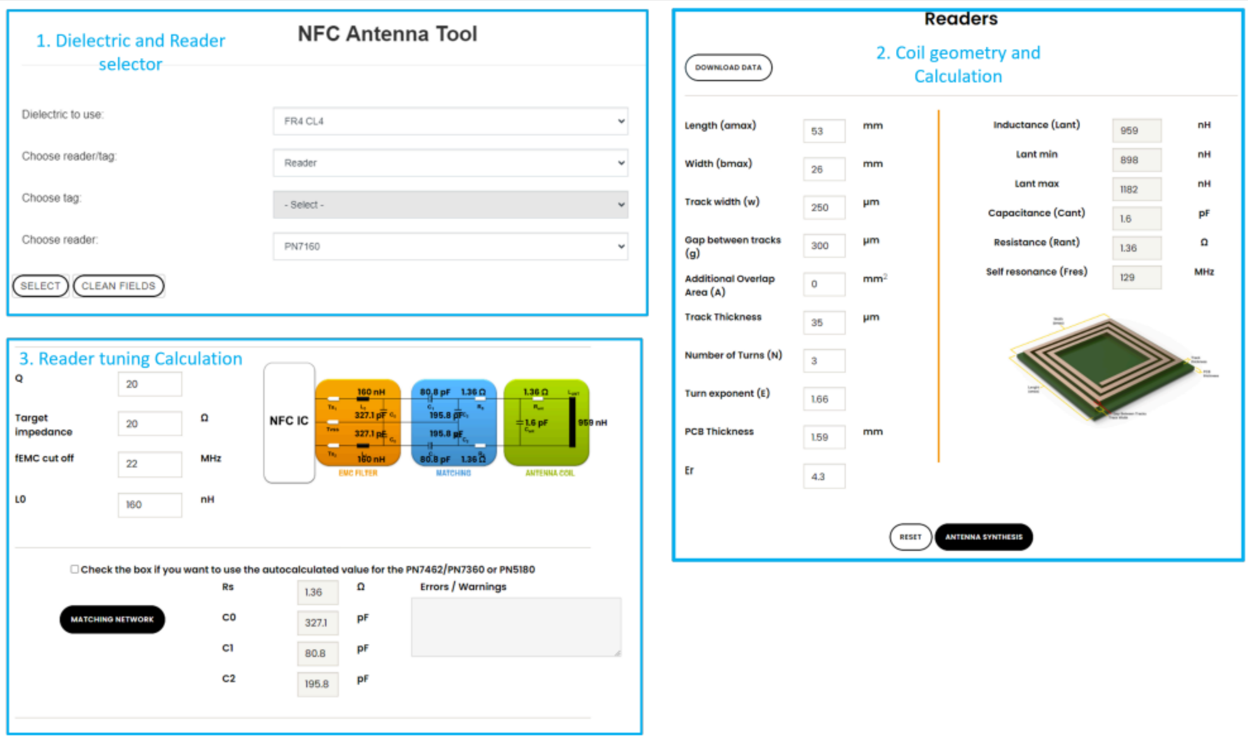

Figure 1. NFC Antenna Design Tool Interface - NFC Readers

Figure 2 shows the NFC Tag Antenna and tuning calculation part.

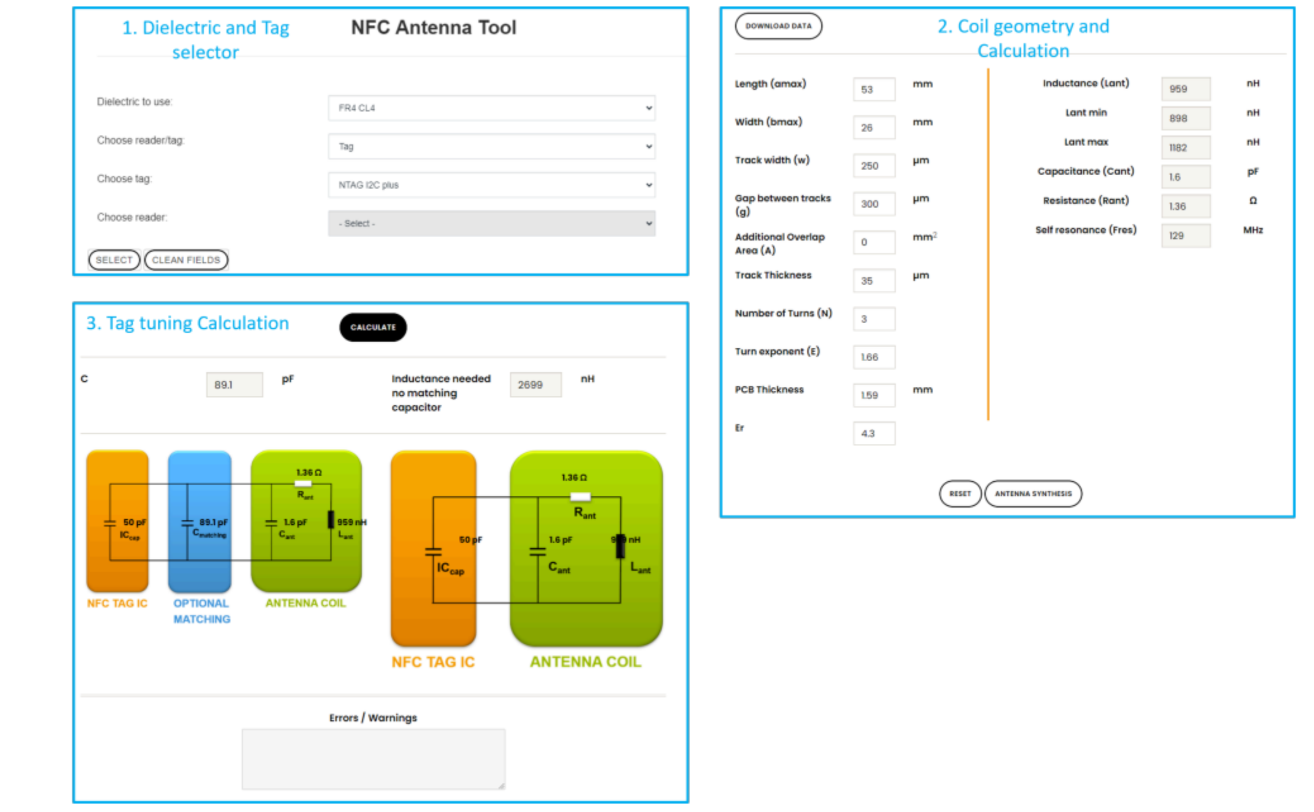

Figure 2. NFC Antenna Design Tool Interface - NFC Tag

Using NFC Antenna Design Tool

Step 1 – Run Online NFC Antenna Design Tool

- Go to [NFC Antenna Design Hub](#) page on NXP website.
- Go to the Downloads section.
- Click DOWNLOAD icon to run the tool (Figure 3).

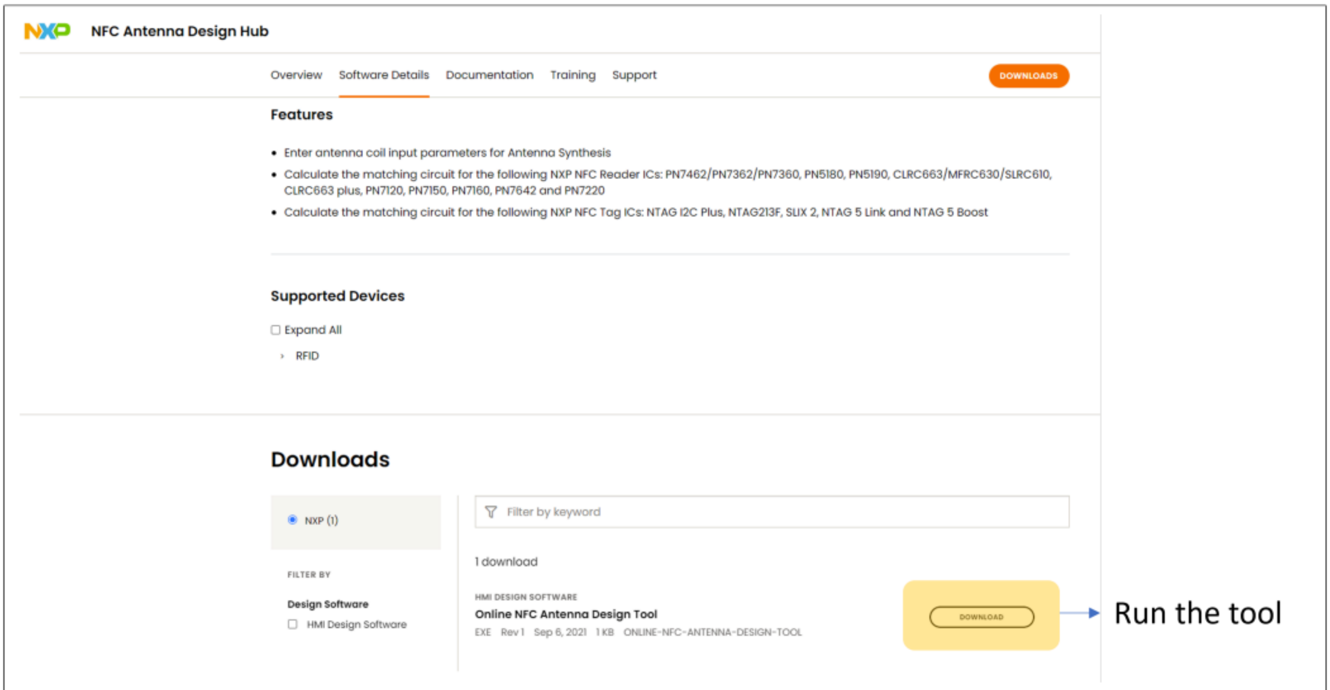

Figure 3. Run Online NFC Antenna Design Tool

Step 2 – Define the input parameters.

- Select the dielectric: choose between FR4 substrate, Flex material, and Air.
- Select one of the available NXP NFC Reader/Tag ICs in the list. The tool provides NXP recommended input values for each IC. You can modify the values can at any time.

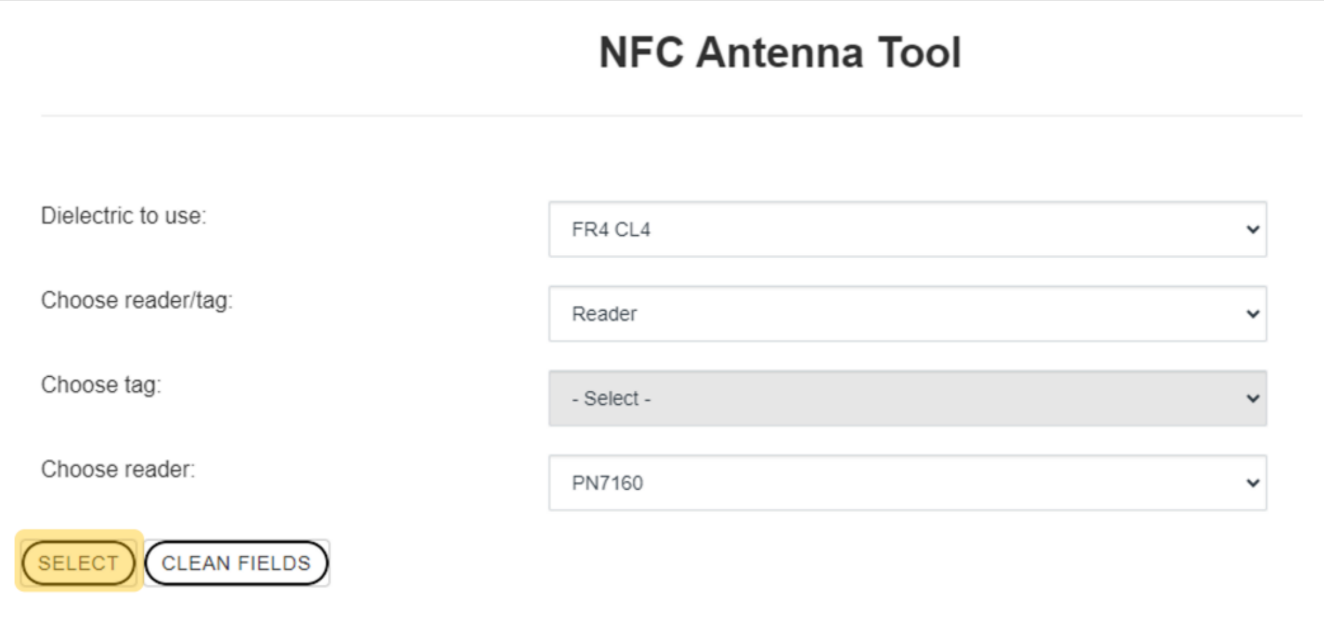

Figure 4. NFC Antenna Tool - Dielectric and Reader selection

Step 3 – Define the antenna coil parameters.
NXP already provided a default value that can be modified.
The input for the antenna coil parameter fields must be a positive number. The tool does not accept any other character. To fill the antenna coil input parameters, follow the recommendations for each NXP NFC Reader IC.

- Set all the parameters.
- Click ANTENNA SYNTHESIS icon.

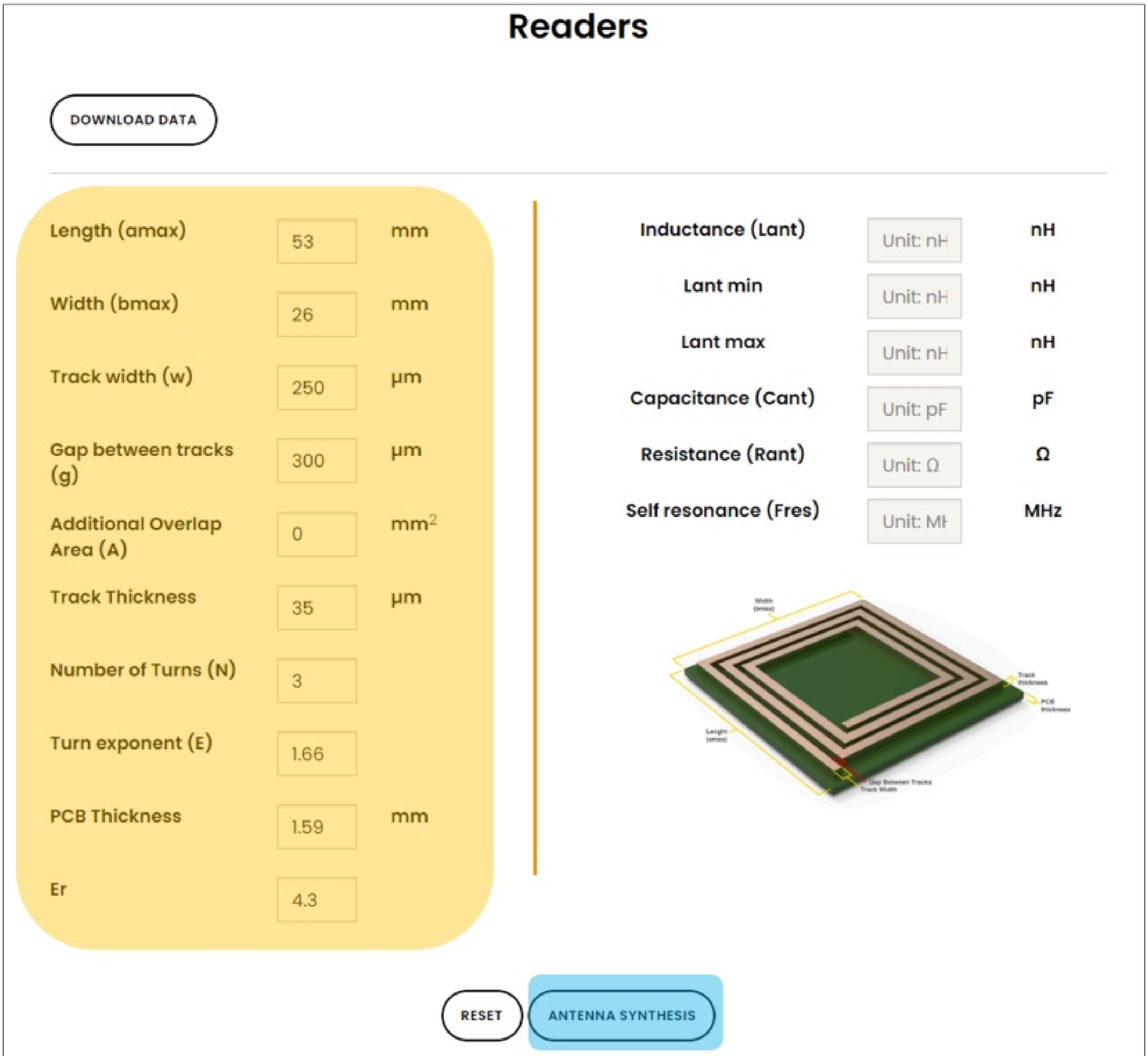

Figure 5. Antenna coil parameters

Step 4 – Check the calculated parameters.
Figure 6 shows the results of the coil parameters calculation (Antenna Synthesis).

- Inductance (Lant)
  – Lant min (represents the border positions depending on corner rounding)
  – Land max (represents the border positions depending on corner rounding)
- Overall capacitance (Cant)
- Overall resistance (Rant)
- Self-resonance frequency (fres)

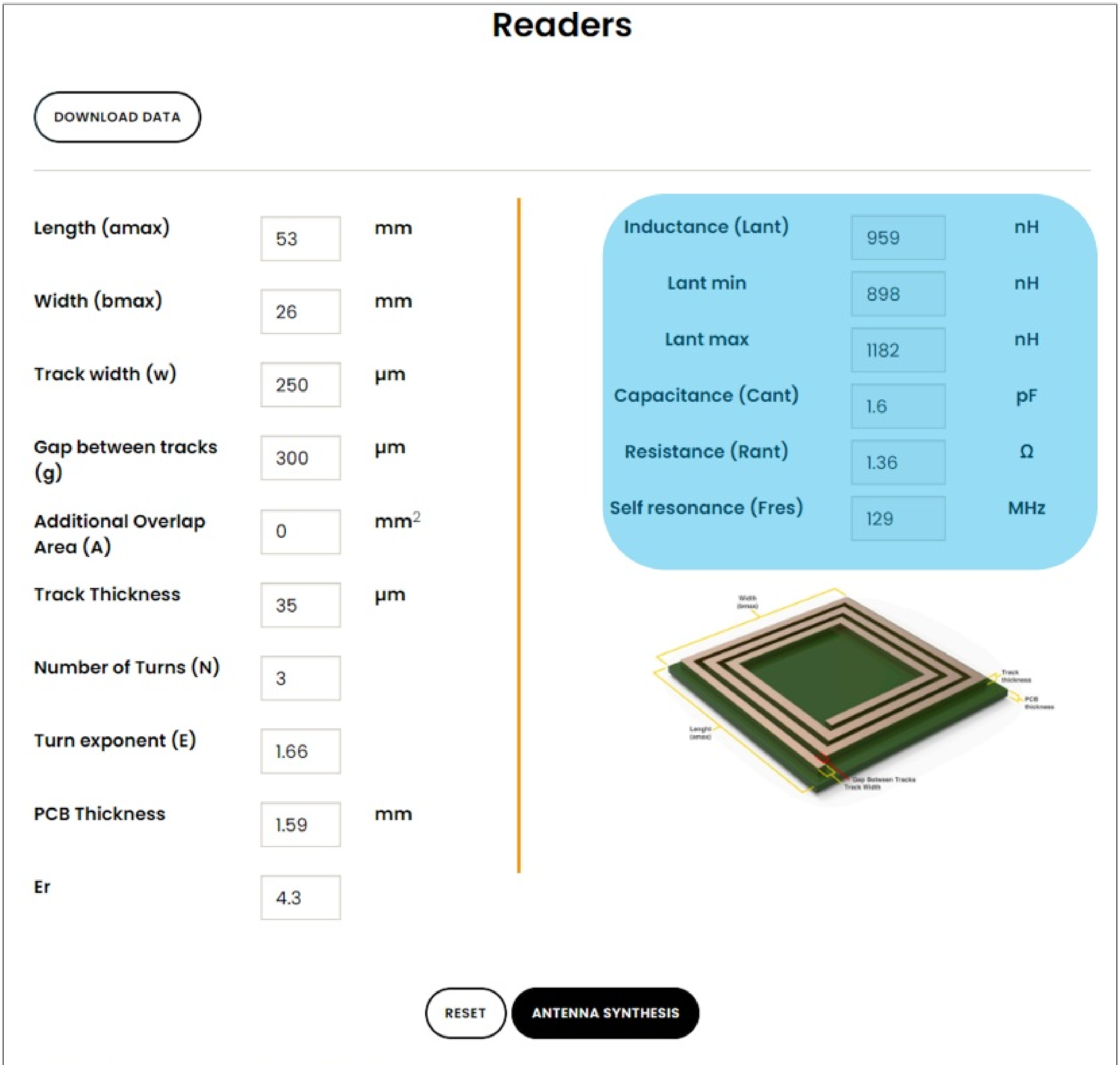

Figure 6. Results of Antenna Synthesis

Step 5 – Get NFC Reader tuning values.
The tool provides NXP recommended input values for each IC. You can modify the values at any time.

- Select the checkbox to get L0 recommended value for PN7462/PN7360 and the PN5180.
- Or, do not select the checkbox and enter a value for L0.
- Click MATCHING NETWORK icon.

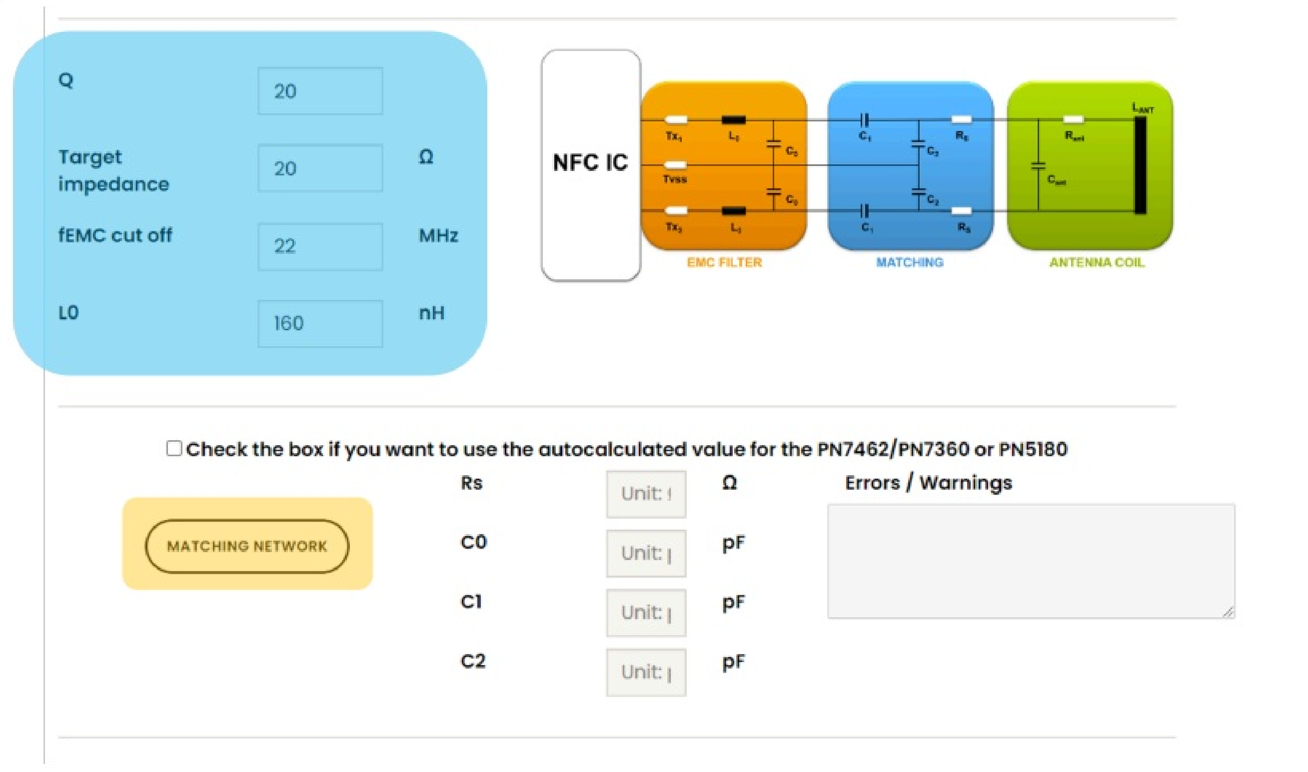

Figure 7. NFC Reader tuning calculation

Step 6 – Check NFC Reader tuning values.

Figure 8 shows the tuning values for NFC Reader.

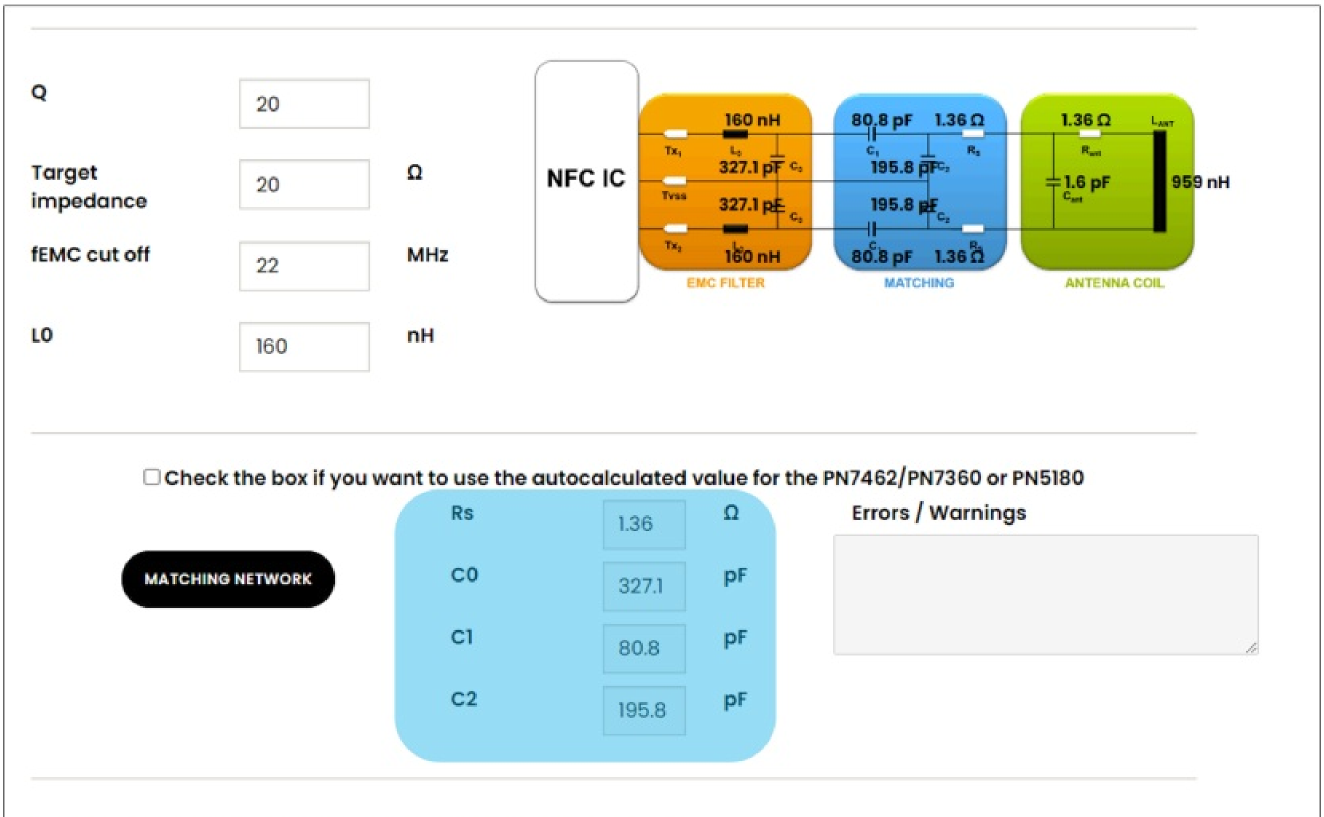

Figure 8. Matching Network values for NFC Reader tuning

Step 7 – Check for errors or warnings.

Figure 9 shows the example of fEMC cut-off frequency set too low.

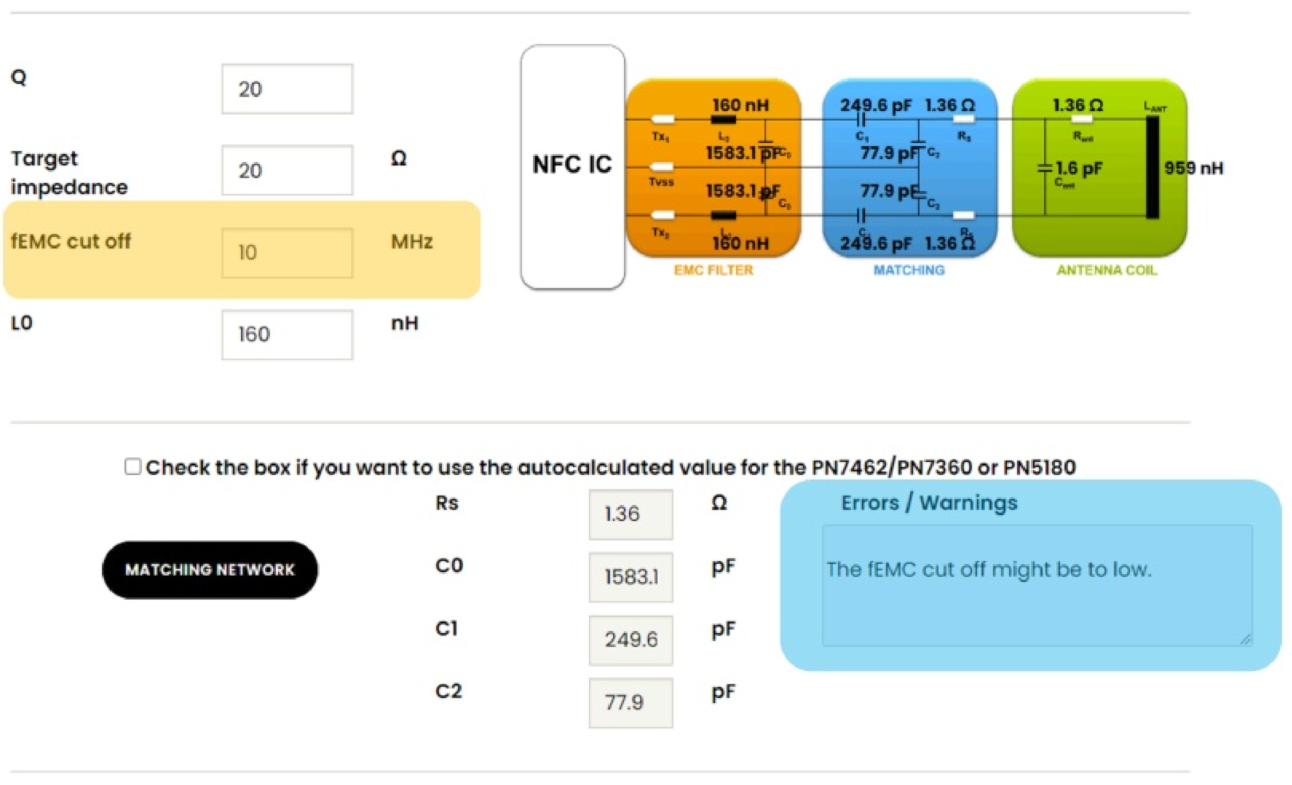

Figure 9. Example of error or warning

Step 8 – Download your data.

- Click the DOWNLOAD DATA icon to download your data in PDF format.

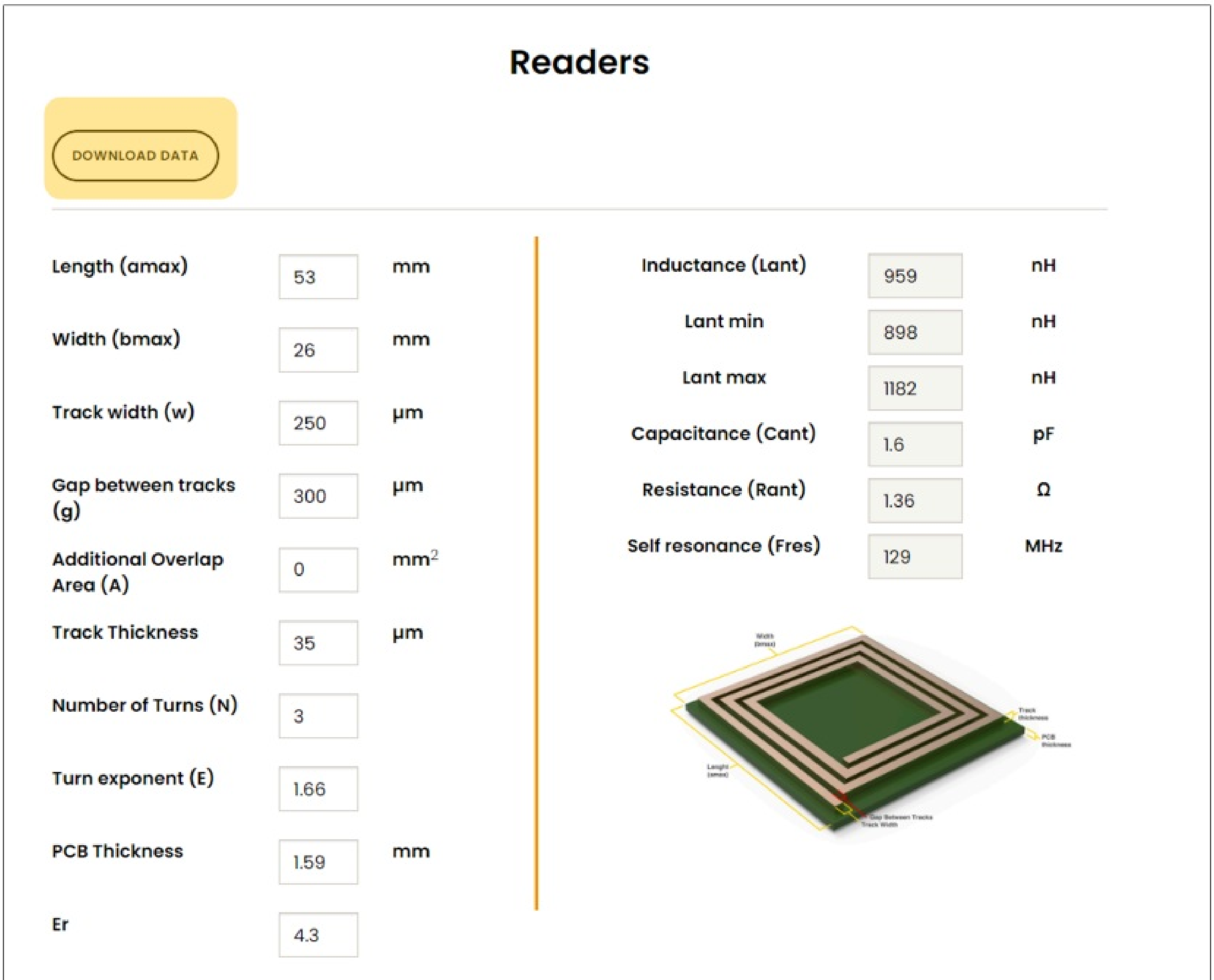

Figure 10. Download your data

References

- NFC Reader ICs:
  - PN7462
  - PN7362
  - PN5180
  - PN5190
  - PN7120
  - PN7150
  - PN7160
  - PN7220
  - SLRC610 Plus
  - CLRC663 plus
- NFC Tag ICs:
  - NTAG I2C Plus
  - NTAG213F
  - SLIX 2
  - NTAG 5 Link
  - NTAG 5 Boost

- Antenna design Gguides:
  - PN7462 family Antenna design guide
  - CLRC663, MFRC630, MFRC631, SLRC610 Antenna Design Guide
  - PN5190 antenna design guide
  - PN7150 Antenna Design and Matching Guide
  - PN7160 antenna design and matching guide
  - PN7120 Antenna Design and Matching Guide
  - NTAG Antenna Design Guide
  - Antenna design guide for NTAG 5 link and NTAG 5 switch

Appendix

Lists of parameters and abbreviations.

Table 1. Antenna synthesis input parameters

Parameter	Description
Length (amax)	The total length of the rectangular antenna coil. The antenna coil outlines are defined by length (amax) and width (bmax). The antenna coil size defines the operating distance. A typica l length value is 50 … 100 mm.
Width (bmax)	The total width of the rectangular antenna coil. The antenna coil outlines are defined by length (amax) and width (bmax). The antenna coil size defines the operating distance. A typical width value is 50 … 100 mm.
Track width (w)	The track width of the antenna coil traces. The tracks should not be too narrow to avoid too hig h losses. On the other side, wider tracks shrink the average antenna area, which reduces the p erformance. A reasonable track width is 500 µm.
Gap between tracks (g)	The distance between the antenna coil traces. This gap should not be too small to avoid a too l ow self- resonance frequency. On the other side, wider gaps shrink the average antenna area, which reduces the performance. A reasonable gap width is 500 µm.
Additional ov erlap area (A)	The additional area, where additional traces cover the antenna coil traces using the other layer , e.g. if additional traces cross the antenna coil traces. Such additional overlap area then slightl y changes the overall antenna behavior. ***Note:*** • *The “normal” overlap area, which is caused by the bridge from the inner trace to the outside (or vice versa) is automatically taken into account. If no additional traces are crossing the ante nna traces, this value is 0.* • *A too large additional overlap area will reduce the performance of the antenna.*
Track thickne ss	The thickness of the copper layer of a PCB. A typical value is 35 µm.
Number of tur ns (N)	The number of turns should be adjusted in a way that a target inductance of the antenna coil a bout 1 µH is achieved. Smaller antennas have more turns than larger ones. A typical antenna of 65 mm x 65 mm has 2 turns. ***Note:*** • *Too many (resp. too less) turns increase (resp. decreases) the inductance too much, which causes some weird tuning parameters.* • *Too many turns can cause a low average area as well as a low self-resonance frequency.* • *The inductance of the antenna coil directly impacts the minimum EMC filter inductance for s ome NXP NFC Reader ICs.*

Turn Exponent (E)	The turn exponent defines the influence of additional turns. It depends on some environmental influences as well as the corner rounding. Typical values are 1.6 … 1.7. The Antenna tool shows a minimum and a maximum value of the estimated inductance, which indicates the possible variation, e.g. depending on corner rounding. ***Note:*** • *Extra metal influence is not taken into account at all.* • *The final inductance of the antenna coil as well as the tuning itself must be measured anyway to adjust the tuning.*
PCB Thickness	The PCB thickness influences the antenna coil via the (normal and additional) overlap area.
Epsilon r (εr)	The relative dielectric constant of the PCB. A typical value of FR4 material is 4.3.
Inductance (Lant)	The result of the antenna coil synthesis, based on the input fields. The target should be a value around 1 µH. This value is taken as input to calculate the tuning. Note: • This synthesis is based on a simple model, and any extra metal influence is not taken into account at all. So, the real value might vary a bit, especially depending on the antenna environment. Especially metal environment close to the antenna coil might decrease the inductance value. • The final inductance of the antenna coil as well as the tuning itself must be measured anyway to adjust the tuning.
Overall capacitance (Cant)	The result of the capacitance of the antenna coil, estimated based on the input fields. This capacitance should be as low as possible. The capacitance value might be higher than calculated, since the antenna synthesis does not take any additional traces into account and assumes an ideal environment. This capacitance value is taken as input to calculate the tuning.
Overall resistance (Rant)	The losses of the antenna coil, given as resistance value. This loss is taken as input to calculate the tuning, and it must be low enough to allow a damping resistor (Rs) > 0 to achieve a realistic tuning. The resistance value in reality might be higher than calculated, since the antenna synthesis does not take any additional traces in to account. Additional connection losses or losses due to metal environment are ignored in this calculation.
Self-resonance frequency (fres)	The self-resonance frequency is just shown as a reference value. The lower this value, the more critical the tuning might become. In any case it must be >30 MHz to allow a proper and stable tuning. A typical theoretical value is above 100 MHz.

Table 2. Antenna tuning input parameters

Parameter	Description
NXP NFC Reader IC choice	Based on the NXP NFC Reader IC choice some basic antenna tuning input parameters are set automatically: Q, Target impedance, and cut-off frequency. Any of the values can be manually modified, if needed.
Q-factor (Q)	The antenna q-factor (requirement) depends on the type of tuning and might vary a lot. Typical values are 15…25, when an NXP NFC Reader IC is chosen. It might be helpful to slightly modif y this value a bit to achieve a reasonable value (E-series!) for the damping resistor Rs. **Example:** The tool might calculate Rs = 0.94 Ω, based on Q = 25. Then it makes sense to cha nge the Q = 24 to get Rs = 1 Ω.
Target imped ance	The target impedance defines the RF power. The typical, nominal value is chosen automaticall y together with the NXP NFC Reader IC. A higher impedance (to reduce the power consumptio n) can always be chosen, but that normally reduces the performance, too.
fEMC cut off	The cut-off frequency of the EMC filter defines the type of tuning ("asymmetrical" or "symmetrical" tuning). The choice of an NXP NFC Reader IC automatically defines this frequen cy. In any case, this frequency should be in the range of 14.5 … 21 MHz.
L0	The EMC filter inductor value. This value can be determined automatically in combination with the used NFC Reader IC and the antenna synthesis, if the checkbox is selected: In case of a D PC tuning the minimum recommended value for the L0 is calculated automatically. It might ma ke sense to manually set this value to the next available real inductor value (E-series!). **Example:** The Antenna tool calculates 386 nH, and the real choice might be 390 nH. This inductor is a critical component in the overall tuning. It must be able to drive the full power level without saturation effects, and it must provide the highest possible Q-factor.

Table 3. Antenna tuning results for Readers

Parameter	Description
Rs	The damping resistor reduces the Q-factor to the required value. This is important to ensure th e required bandwidth. It is important to choose a resistor, which can survive the proper power l evel. It might make sense to place two resistors (double the resistance value) in parallel to cov er the required power level.
C0	The C0 defines the cut-off frequency (in combination with L0). Together with L0 it must be plac ed as close to the NXP NFC Reader IC as possible to keep the radiation of unwanted harmonics as low as possible. It might make sense to provide two capacitors in parallel for eac h C0 to be able to achieve the required value. Consider the voltage rating!
C1	The serial capacitance should not get < 15 … 20 pF, otherwise the overall performance might b e reduced. The tolerances must be considered! It might make sense to provide two capacitors for each C1 in parallel to be able to achieve the required value. Consider the voltage rating!
C2	The parallel capacitance normally is in the range of > 100 pF. The overall tuning gets unreliabl e, if the C2 < 50 pF. The tolerances must be taken into consideration! It might make sense to p rovide two capacitors for each C2 in parallel to be able to achieve the required value. Consider the voltage rating!

Table 4. Antenna tuning results for Tags

Parameter	Description
C	Parallel tuning capacitance
Inductance needed no matching capacitor	This value indicates the antenna inductance value for which the tuning capacitor is not required. The tuning i s done with the help of the IC internal capacitance. If t he inductance value is higher than this value, the NFC Tag cannot be properly tuned.

Revision history

Table 5. Revision history

Document ID	Release date	Description
UM11232 v.2	8 February 2024	• Added NFC Readers: PN7160, PN7220. • Added NFC Tags: NTAG I2C Plus, NTAG213F, SLIX 2, NT AG 5 Link and NTAG 5 Boost. • Section 2 “Application overview”: updated. • Section 3 “Using NFC Antenna Design Tool”: updated. • Section 4 “References”: updated.
UM11232 v.1	3 June 2019	• Initial version

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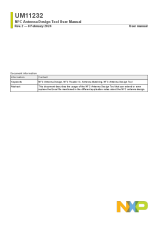	NXP UM11232 NFC Antenna Design Tool [pdf] User Manual UM11232 NFC Antenna Design Tool, UM11232, NFC Antenna Design Tool, Antenna Design To ol, Design Tool

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