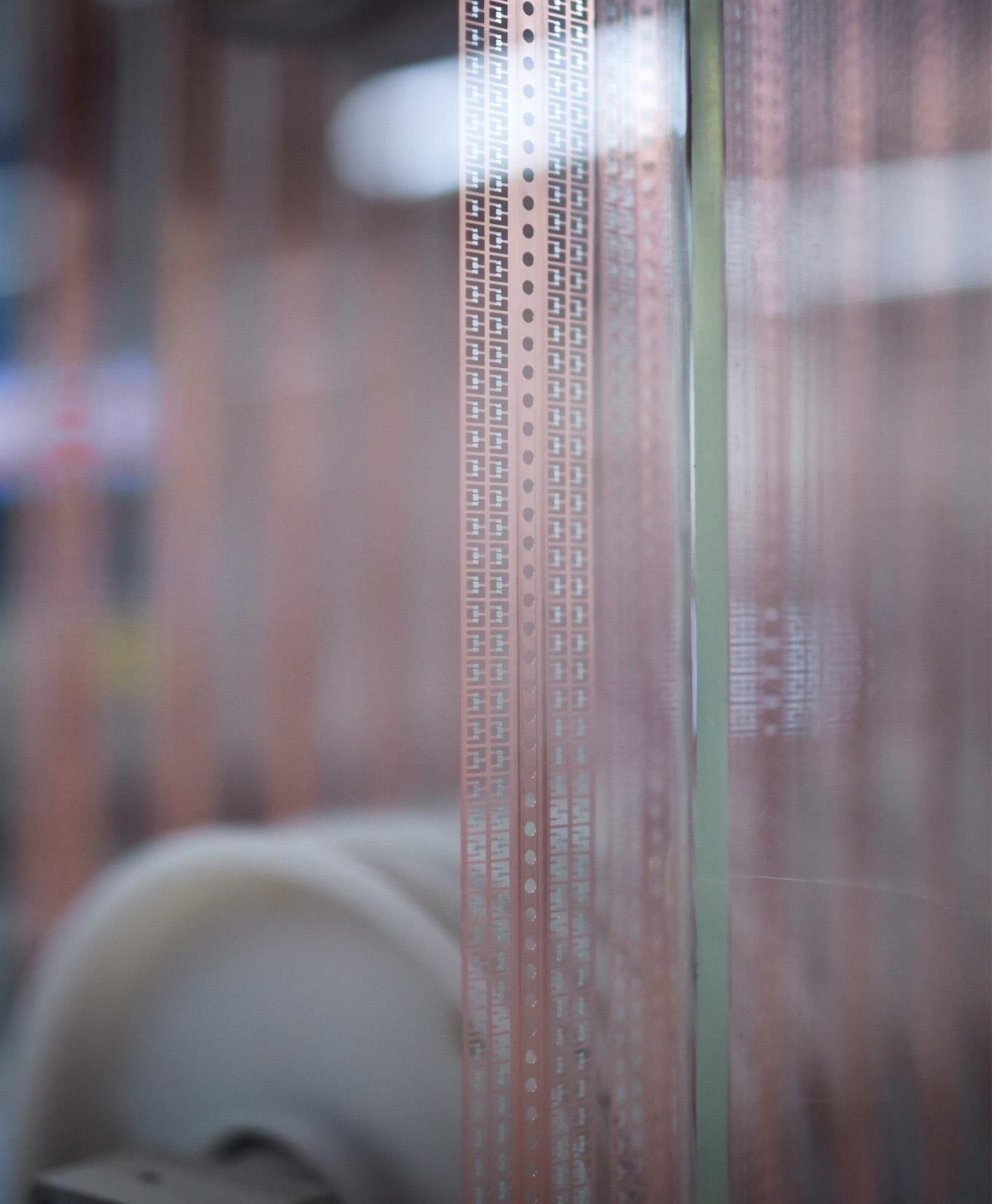
DESIGN YOUR NFC ANTENNA WITH NXP'S OM29263ADK DEVELOPMENT KIT

JORDI JOFRE
NFC EVERYWHERE
JUNE 2018

SECURE CONNECTIONS FOR A SMARTER WORLD



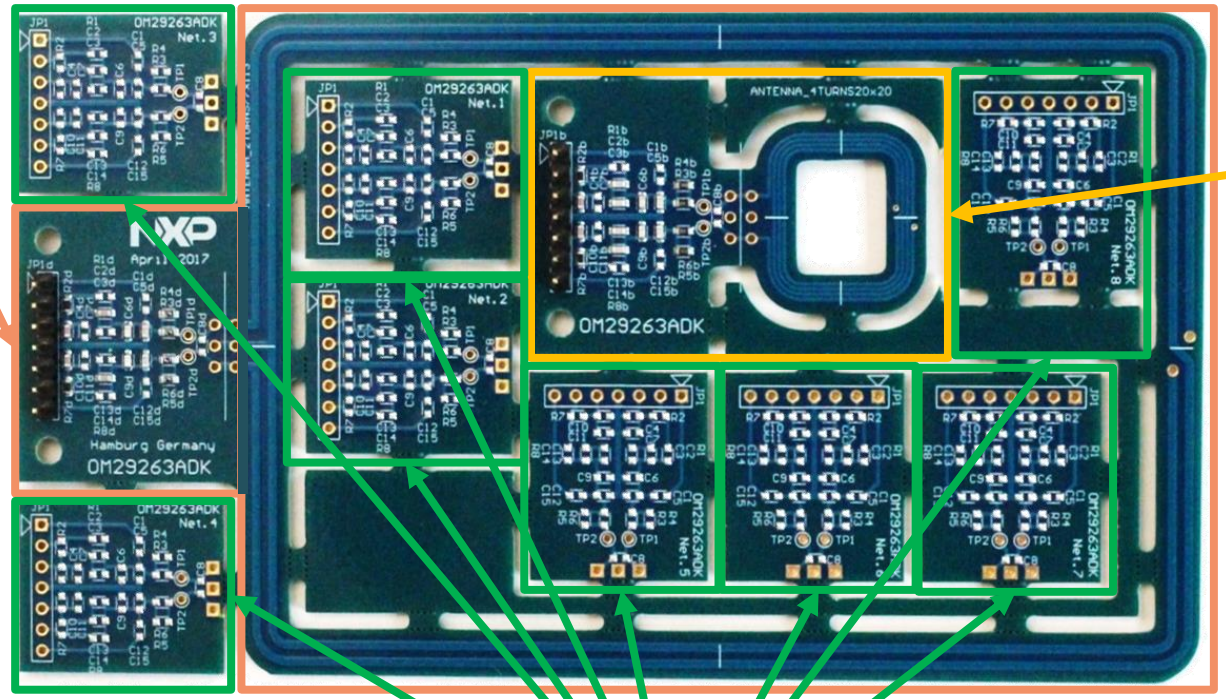
Agenda

- OM29263ADK kit overview.
- Using OM29263ADK kit with CLEV6630A, CLEV6630B, PNEV5180B or PNEV7462C
- Using OM29263ADK kit to connect your own antenna coil
- Using OM29263ADK kit to evaluate the performance of different antenna shapes

OM29263ADK kit overview

OM29263ADK contents

2 turns 77×113mm² antenna
For best performance with ICODE ILT or MIFARE® including DESFIRE® family

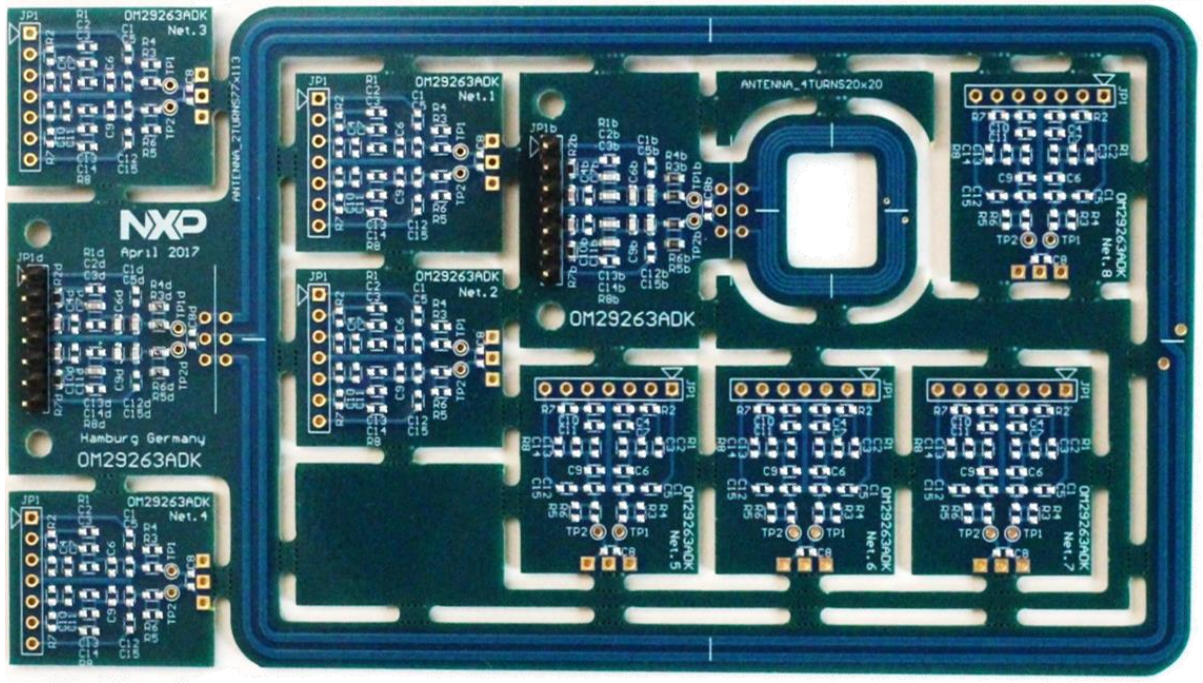


4 turns 20×20mm² antenna
Optimal to interact with mobile phones, NTAG® family or ICODE® SLIX/DNA where footprint is limited

8 PCBs for individual antenna matching

Training Mobile Knowledge

OM29263ADK NFC Antenna Development Kit



Part number complete kit: OM29263ADK
12NC: 935361598598
Ordering: eCommerce

OM29263ADK can be:

- Directly connected to the CLEV6630A or the CLEV6630B development board
- Tuned to connect to the PNEV5180B or the PNEV7462C development board
- Used to connect and tune any antenna coil to any of the NFC reader evaluation boards

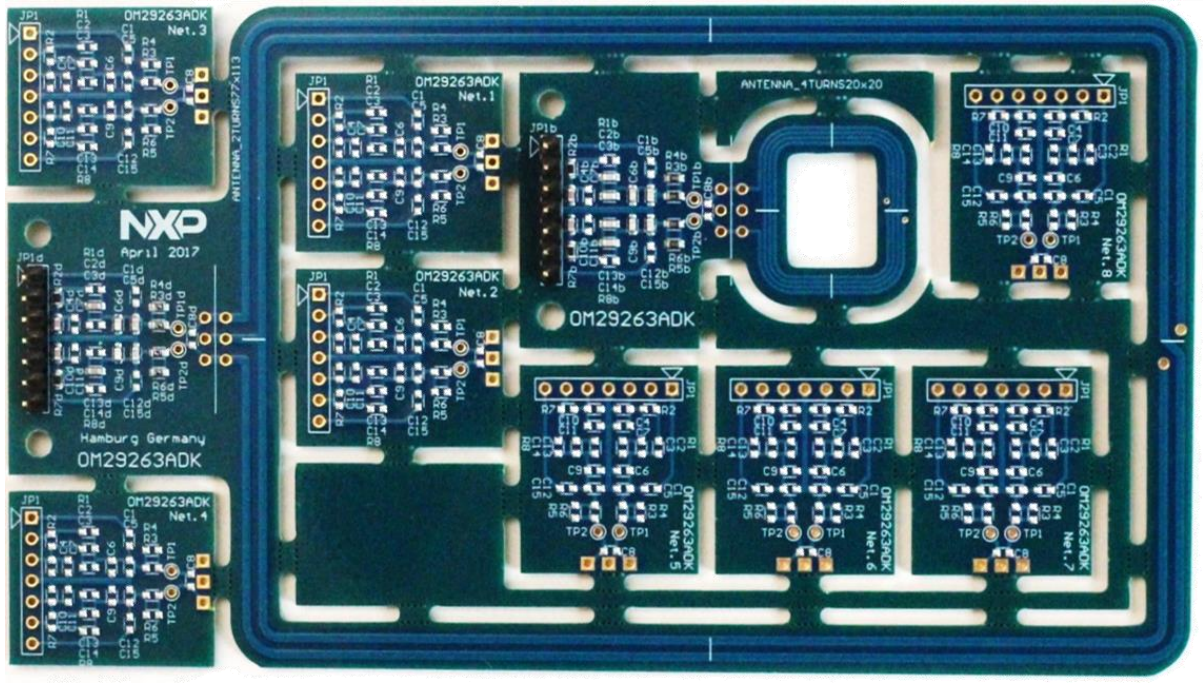
OM29263ADK is the perfect tool for:

- Evaluating the performance of different antenna shapes
- Prototyping your antenna design quickly

Training Mobile Knowledge

Using OM29263ADK kit with CLEV6630A or CLEV6630B

OM29263ADK NFC Antenna Development Kit



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Now

OM29263ADK can be:

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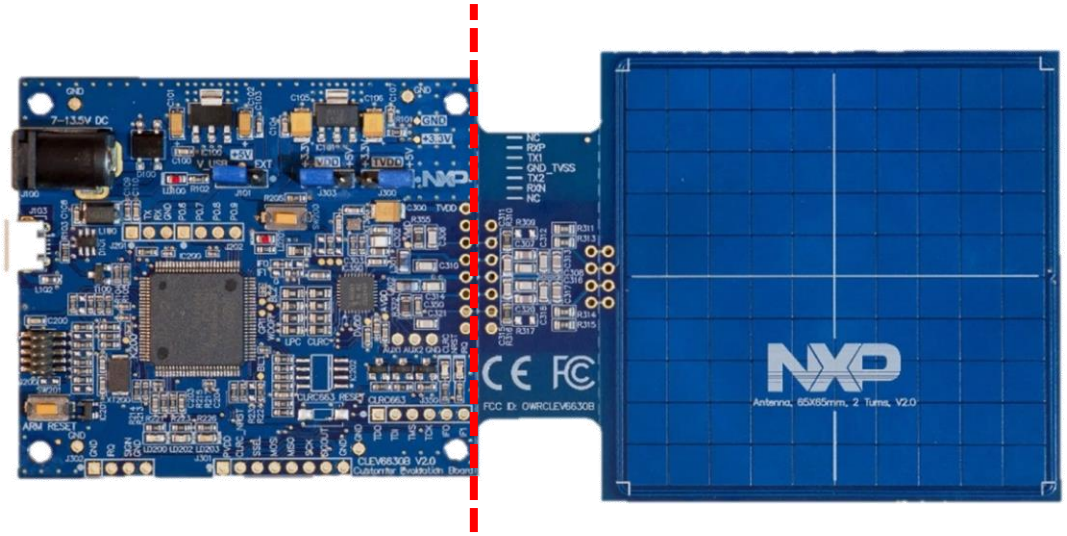
Training Mobile Knowledge

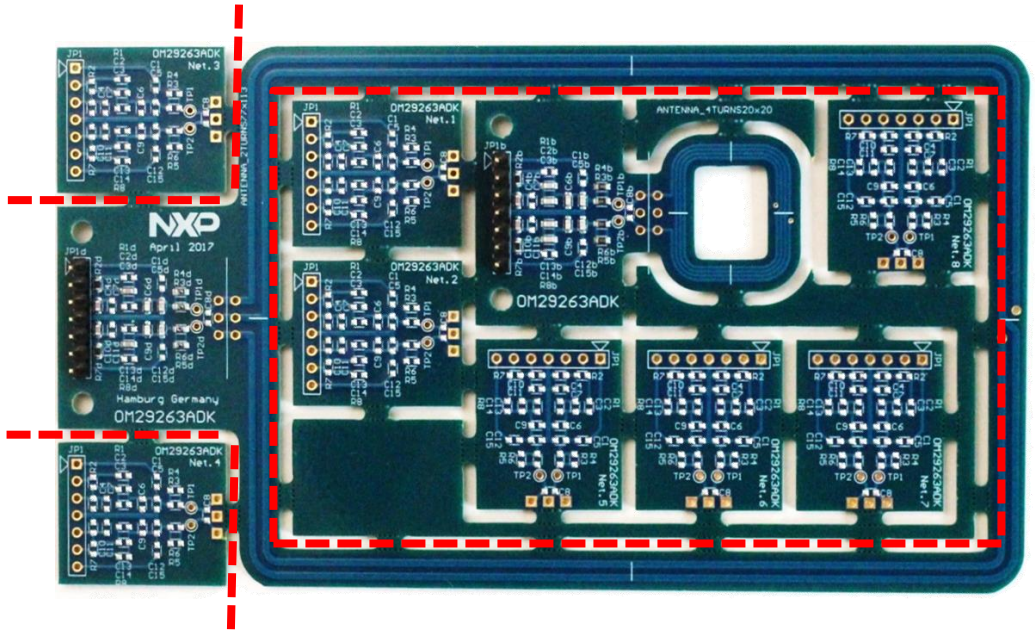
Hardware preparation (I)

Step 1:
Separate the antenna and the matching from the main board



Part number board only: CLEV6630B
12NC: 935339149699

Step 2:
Separate the large antenna from the other PCBs



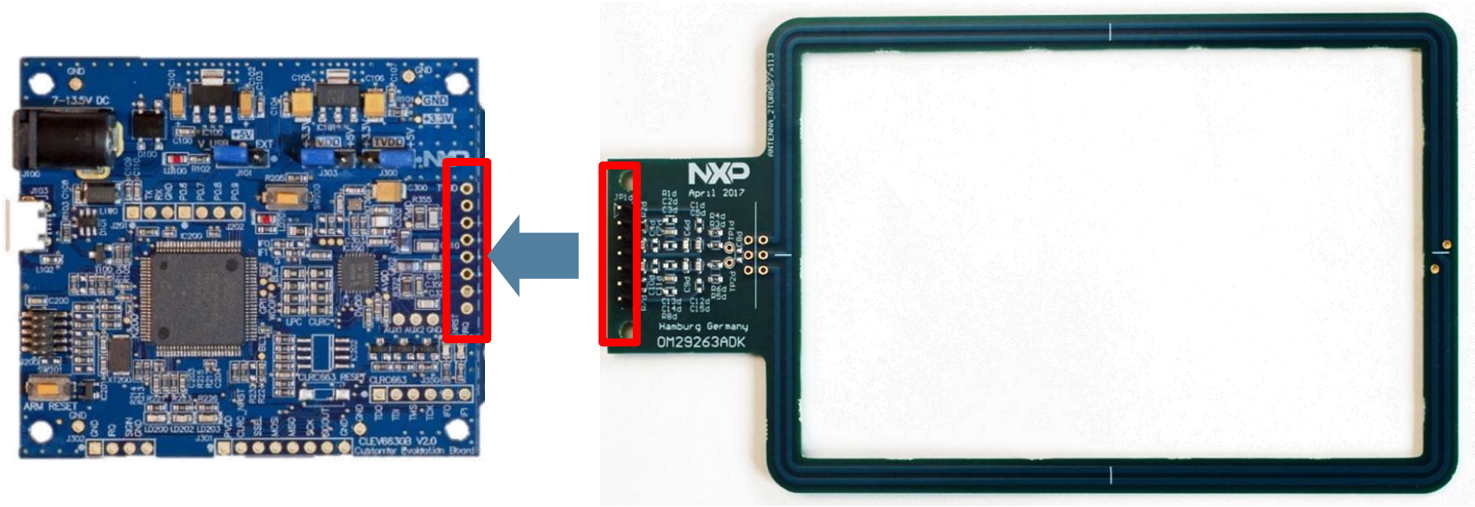
Part number complete kit: OM29263ADK
12NC: 935361598598
Ordering: eCommerce

Use the cut lines to easily separate the different PCB sections

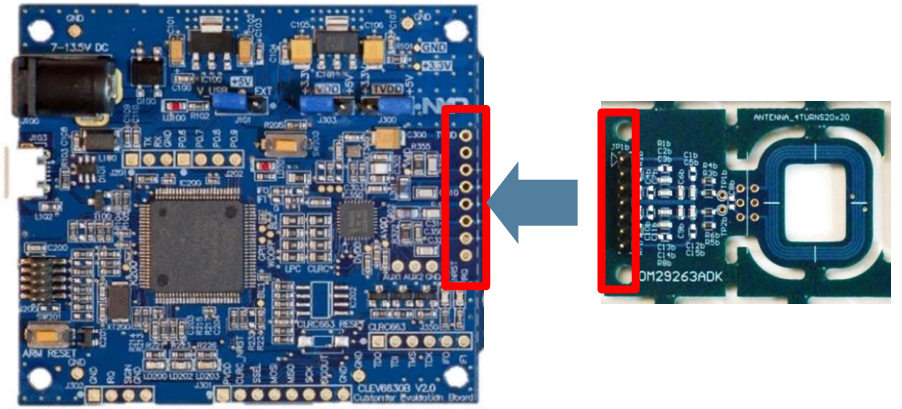
Training Mobile Knowledge

Hardware preparation (II)

Step 3:
Replace the CLEV6630B original antenna by the OM29263ADK large antenna



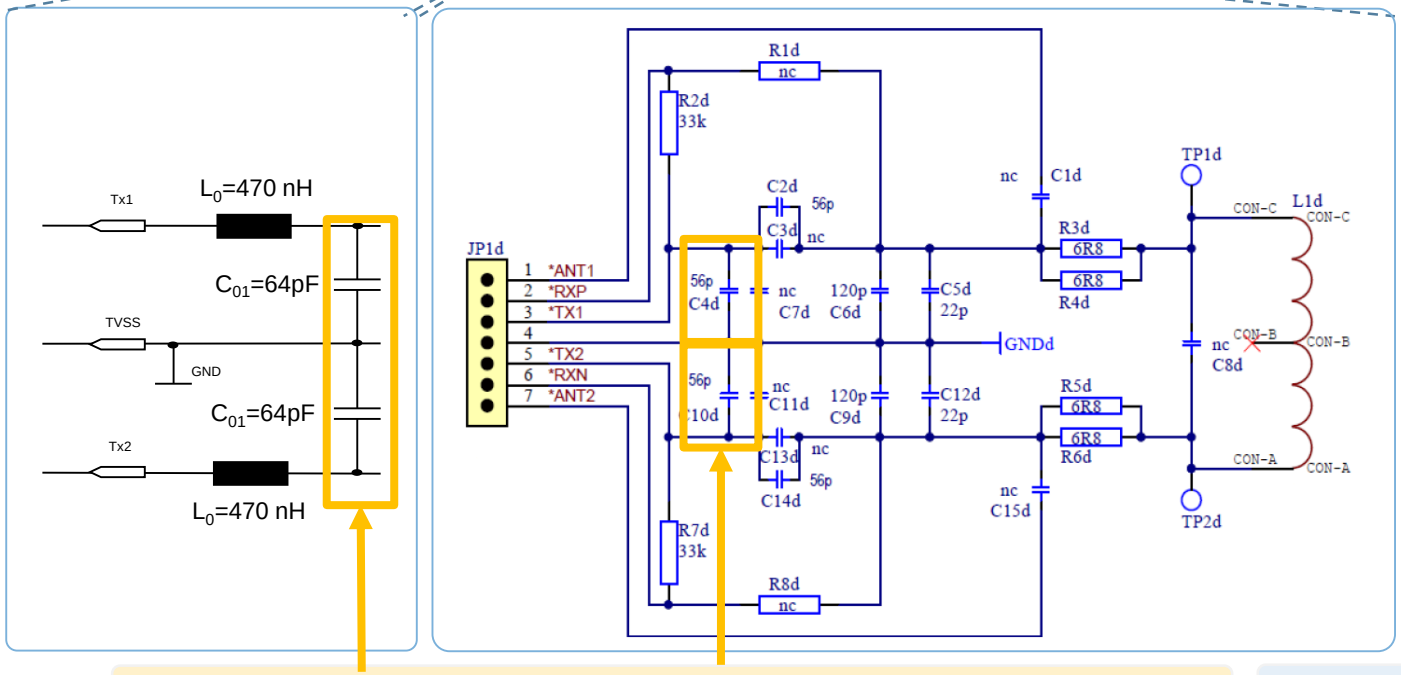
Step 4:
Replace the CLEV6630B original antenna by the OM29263ADK small antenna



OM29263ADK antenna's includes a 7 pin row connector, which fits directly to CLEV6630B

Training Mobile Knowledge

CLEV6630B or CLEV6630A with OM29263ADK large antenna



$Z \sim 19\ \Omega$

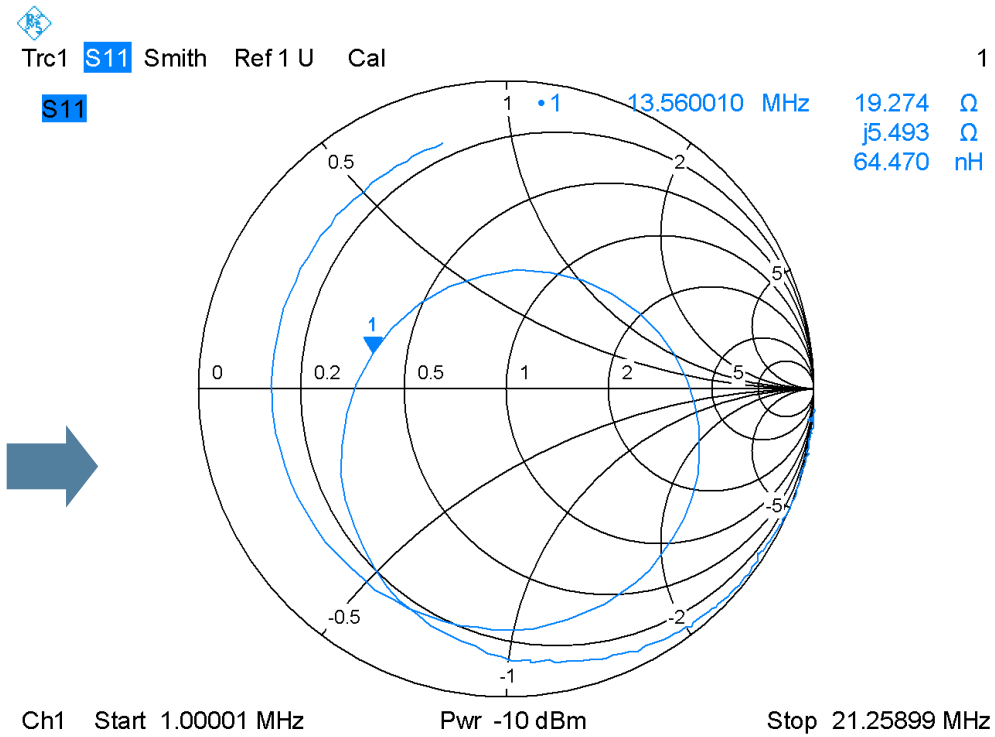


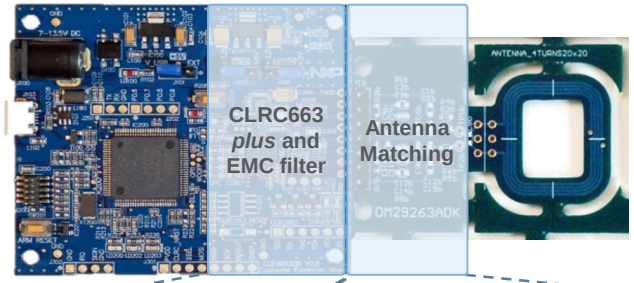
Fig. Impedance measurement done with Rohde & Schwarz ZVL

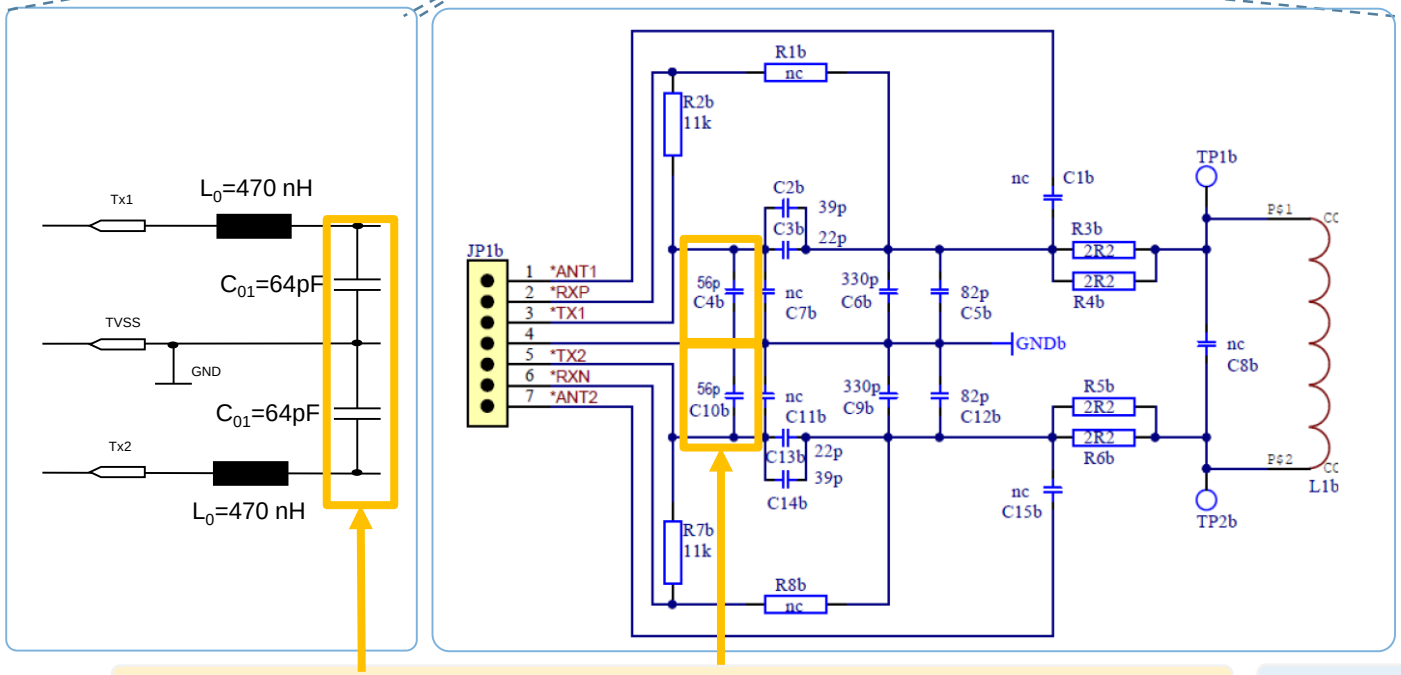
CLEV6630A and CLEV6630B EMC filter L0=470nH C0=124pf

- L0 and C0 = 68pF are assembled on the main board
- C0 = 56pF are assembled on the antenna board

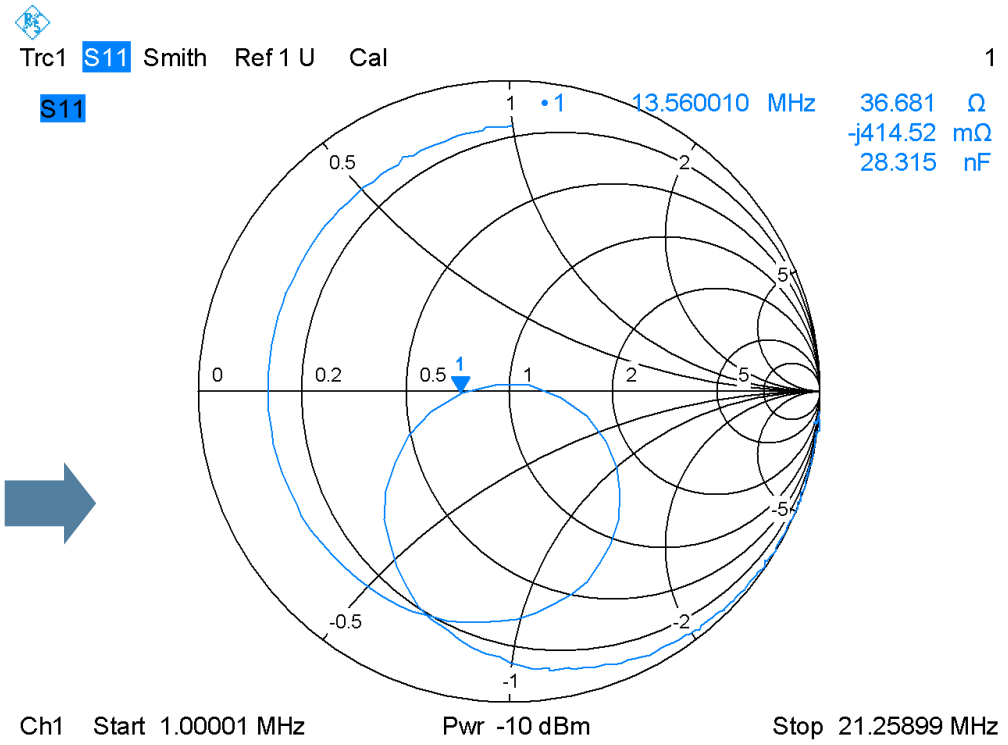
OM29263ADK large antenna can be directly connected to the CLEV6630A or CLEV6630B without any additional modification

CLEV6630B or CLEV6630A with OM29263ADK small antenna





$Z \sim 36\ \Omega$



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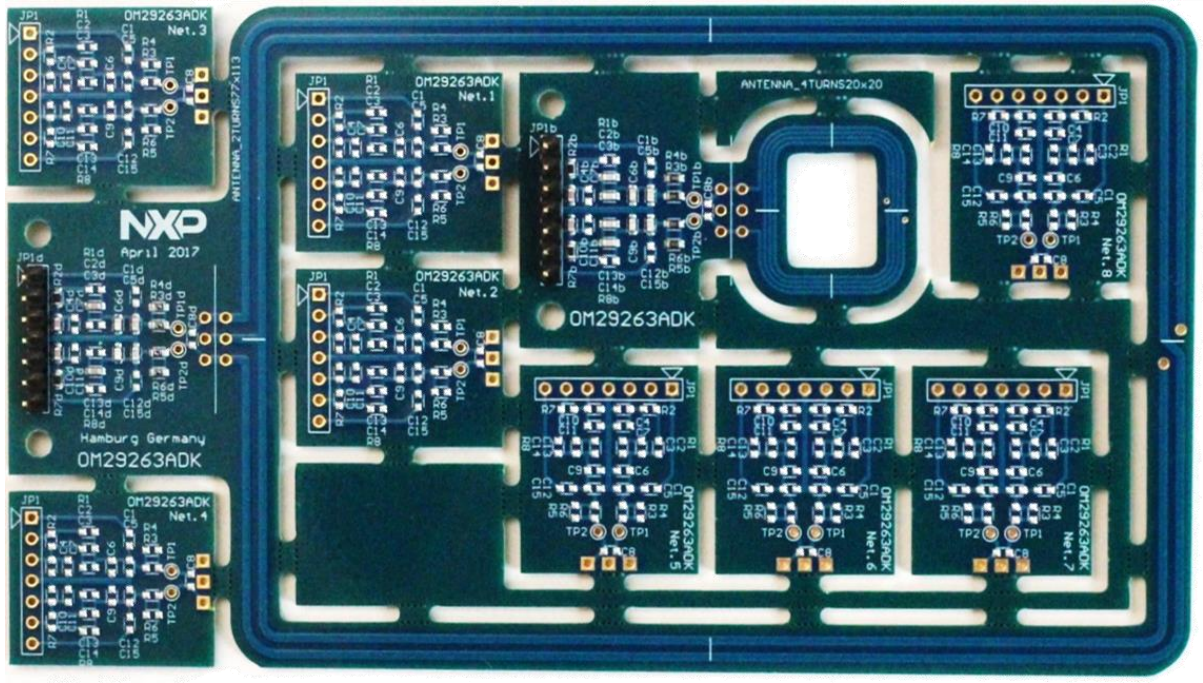
Using OM29263ADK kit with PNEV5180B or PNEV7462C

OM29263ADK NFC Antenna Development Kit



Part number complete kit: OM29263ADK
12NC: 935361598598
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OM29263ADK can be:

- Directly connected to the CLEV6630A or the CLEV6630B development board
- **Tuned to connect to the PNEV5180B or the PNEV7462C development board**
- Used to connect and tune any antenna coil to any of the NFC reader evaluation boards

Now

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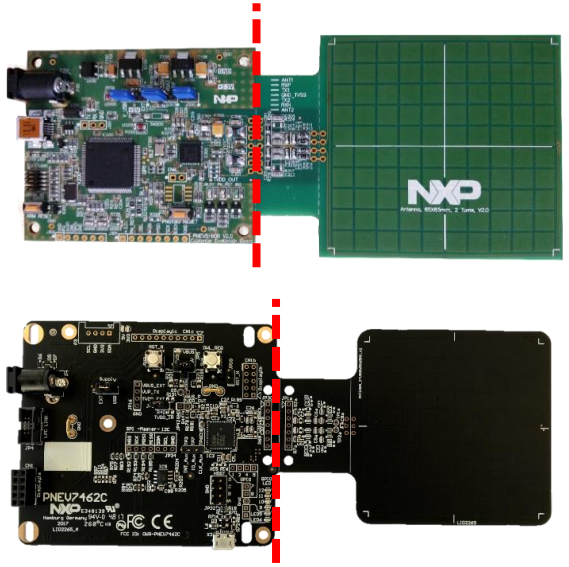
- Evaluating the performance of different antenna shapes
- Prototyping your antenna design quickly

Training Mobile Knowledge

Hardware preparation steps

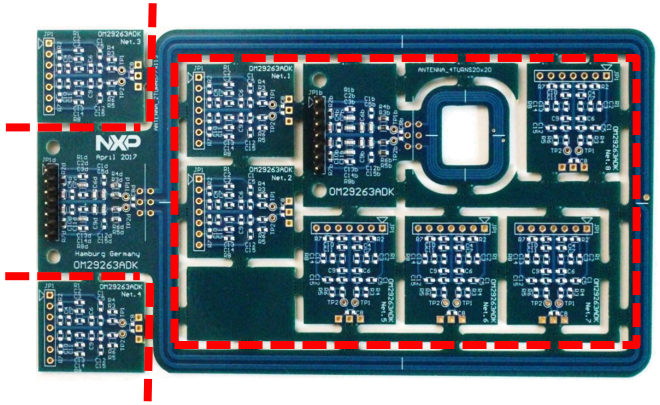
Separate the antenna and the matching from the NFC Reader evaluation board



Part number board only: PNEV5180B
12NC: 935307321699

Part number board only: PNEV7462C
12NC: 935363525598

Separate the large / small antenna from the other PCBs



Part number complete kit: OM29263ADK
12NC: 935361598598
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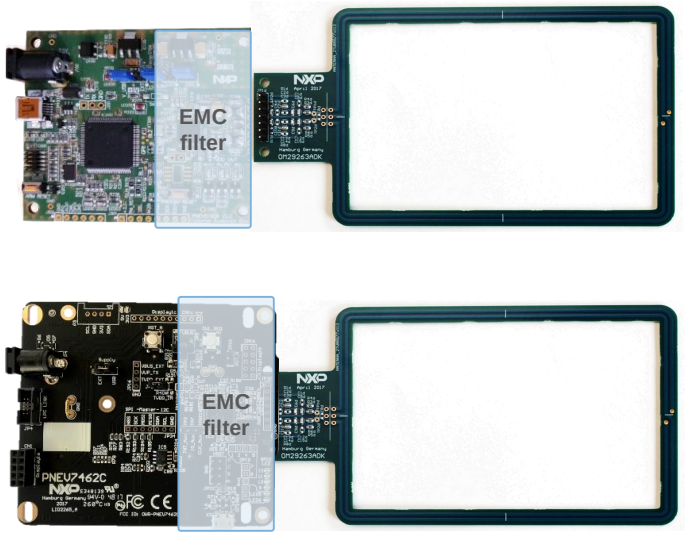
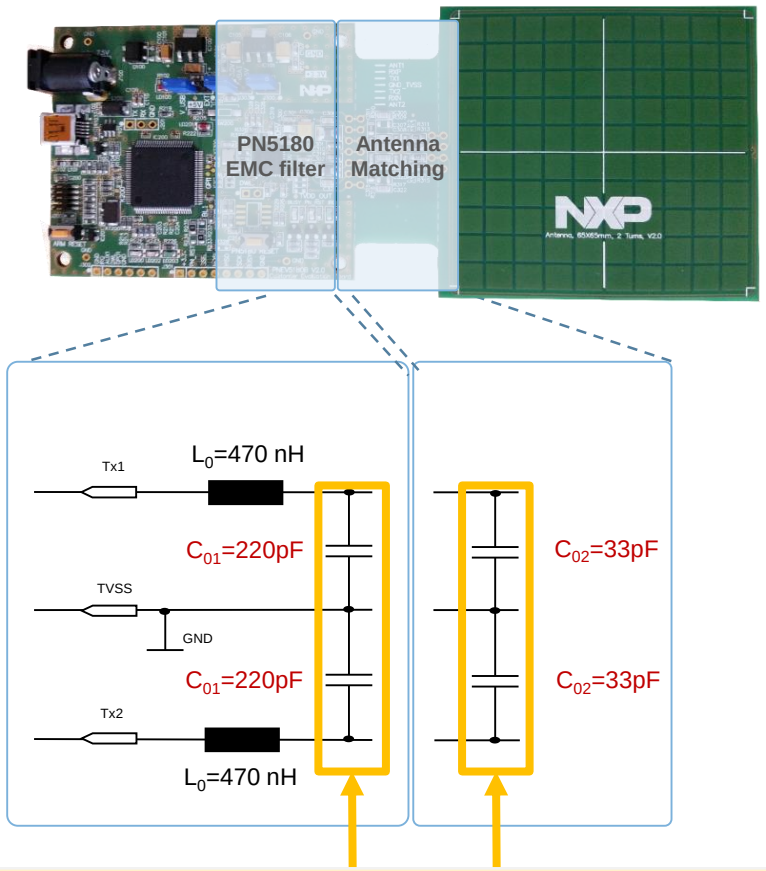
Adapt EMC filter cutoff frequency for asymmetric antenna tuning



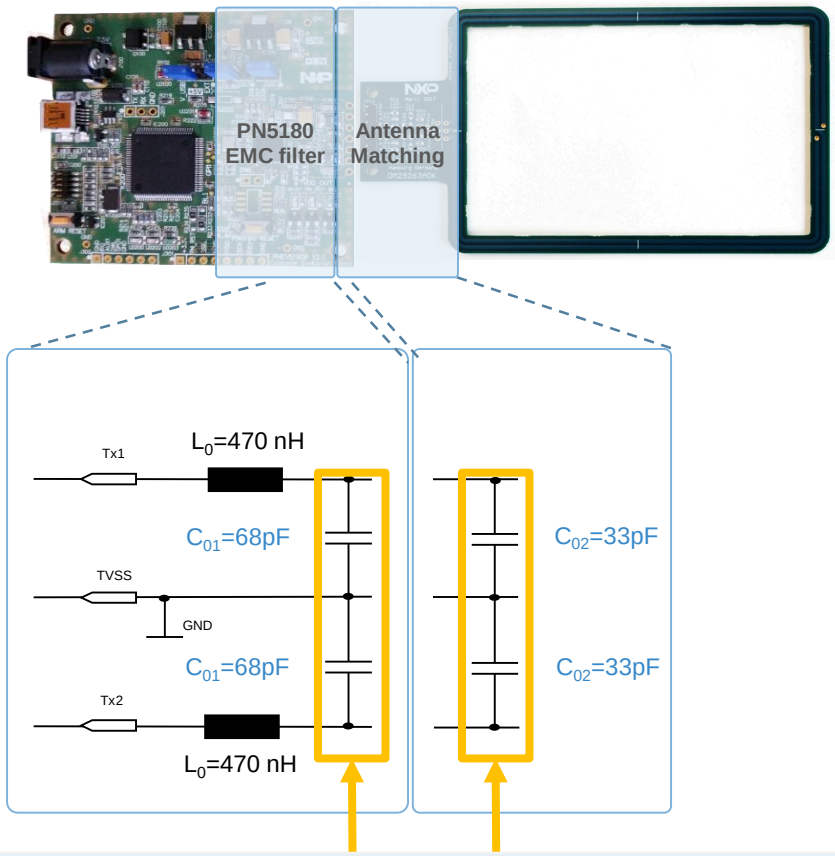
Training Mobile Knowledge

PNEV5180B or PNEV7462C with OM29263ADK antennas



The original antenna in PNEV5180 and PNEV7462C uses a symmetrical tuning. EMC filter with:

- L0 = 470nH and C0 = 253pF (220pF + 33pF)

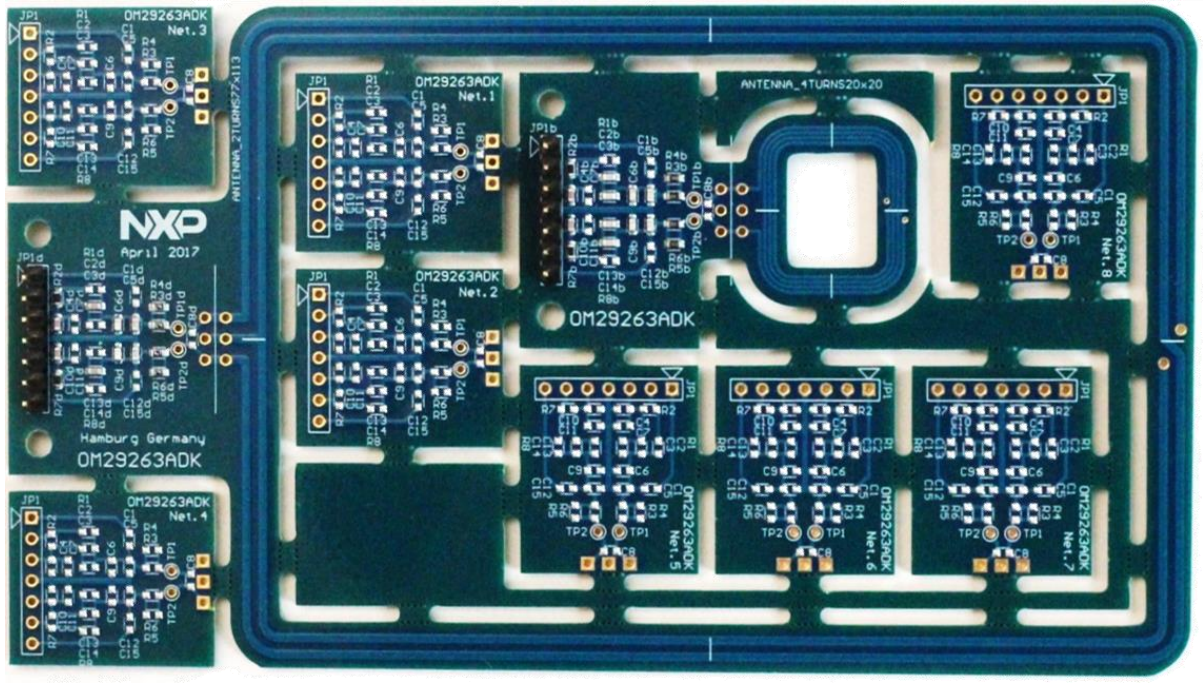


The C0 in PNEV5180B or PNEV7462C (220pF) must be replaced by a 68pF to operate the OM29263ADK antennas ‘as they are’ (i.e. with a proper matching adaptation)

Training Mobile Knowledge

Using OM29263ADK kit to connect your own antenna coil

OM29263ADK NFC Antenna Development Kit



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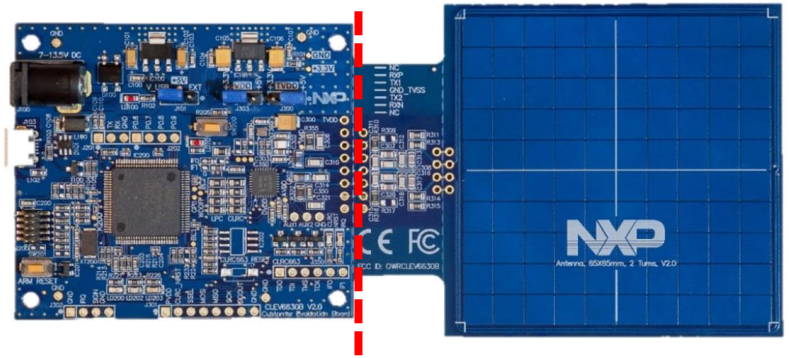
Training Mobile Knowledge

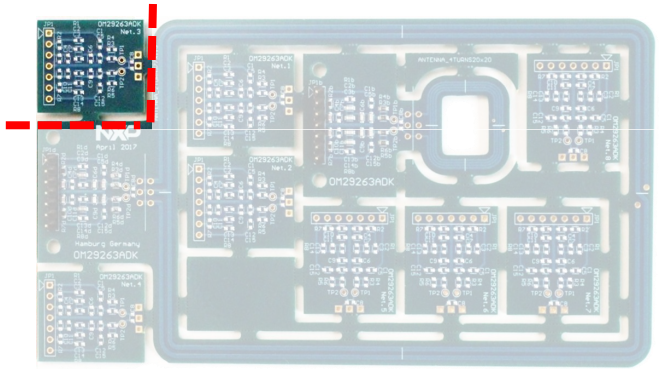
Hardware preparation steps

Separate the antenna and the matching from the NFC Reader evaluation board



Part number board only: CLEV6630B
12NC: 935339149699

1 PCB antenna matching from the OM29263ADK board



Part number complete kit: OM29263ADK
12NC: 935361598598
Ordering: eCommerce

11x11cm 2-turn PCB antenna

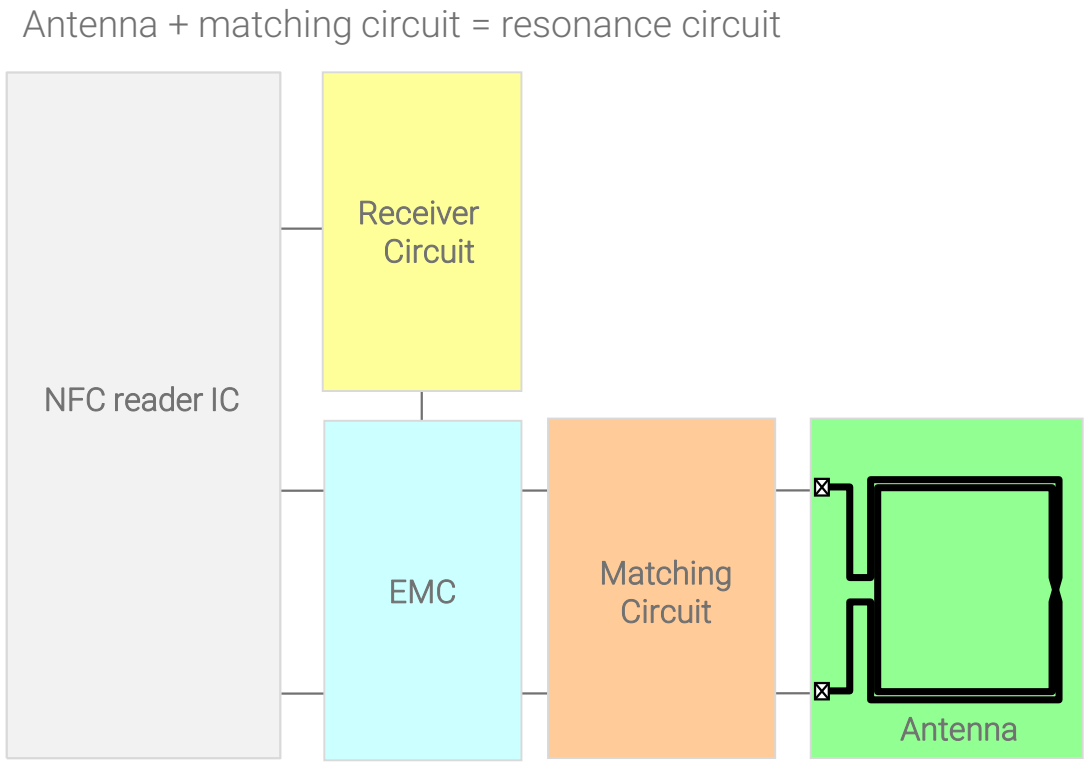
Part: Any customer antenna can be used. This one is used as an example

This section shows how this sample antenna from our lab was tuned using OM29263ADK

Training Mobile Knowledge

NFC antenna tuning steps

1. Define target impedance and Q-factor
   To optimize RF output power or battery life
2. Measure antenna coil
   Characterize R,L,C antenna coil parameters
3. Design EMC Filter
   Filtering unwanted harmonics
4. Calculate matching circuit components
   Use NXP antenna design tools
5. Assemble & measure
   Impedance measurement in the field
6. Fine tune matching components
   Simulation and matching adjustment according to measurements in the field
7. Adjust receiver circuit
   Tune receiver sensitivity



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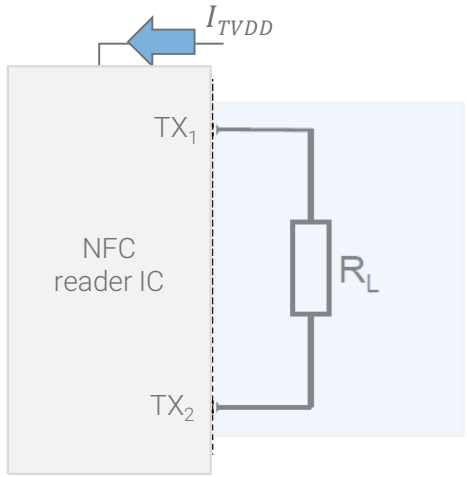
Adjustment of the target impedance the NFC reader IC "sees" according to the performance we want to achieve (e.g., Maximum output power, minimum current consumption)



Antenna and Matching circuit

Selected target impedance for our antenna tuning: $Z \sim 20\ \Omega$

Selected Q-factor for our antenna tuning: $Q \sim 25$

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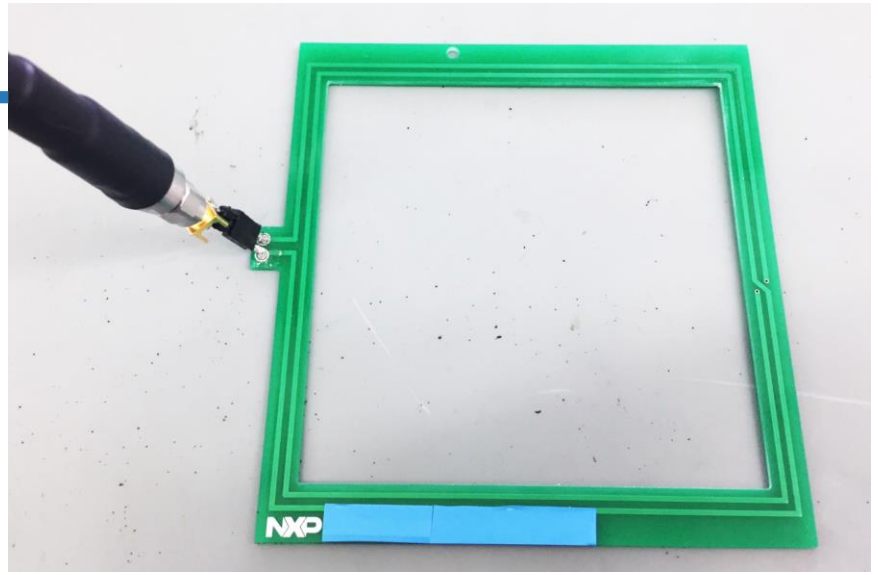
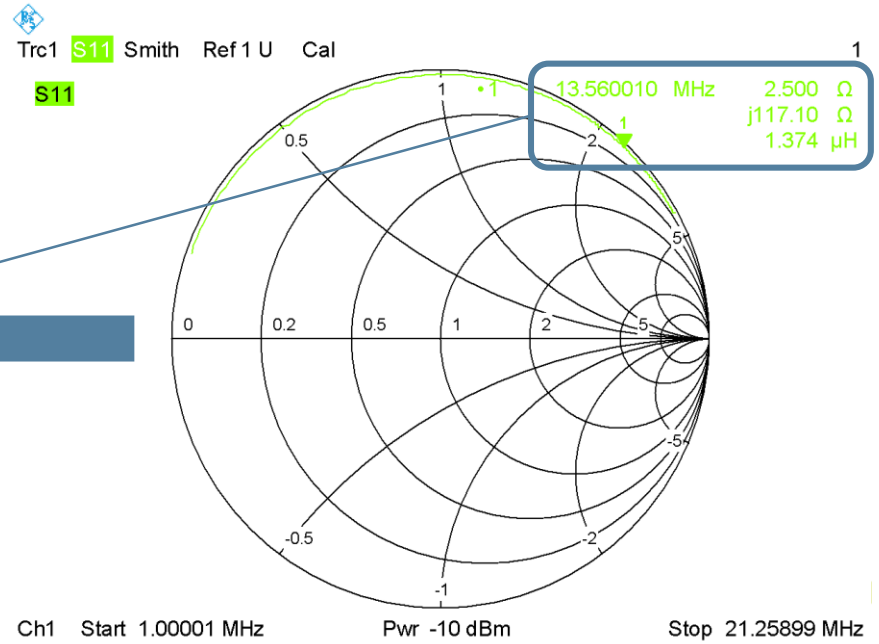
Network vector analyzer



$L_a \sim 1.3\ \mu H$

$R_a \sim 2.5\ \Omega$



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EMC filter cutoff frequency for asymmetric antenna tuning (fc):

$$f_c = 14.5\ MHz\ \ldots\ 22\ MHz$$

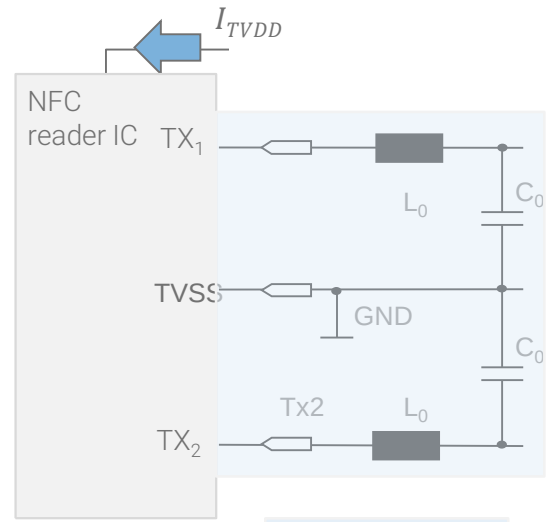
Range of values has proven to be very useful in practice:

$$L_0 = 330\ nH\ \ldots\ 560\ nH$$

Selected fc: $f_c = 21\ MHz$

Selected L0: $L_0 = 470\Omega$

Selected C0: $C_0 = 120\ pF$



EMC filter

$$C_0 = \frac{1}{(2 \cdot \pi \cdot fc)^2 \cdot L_0}$$

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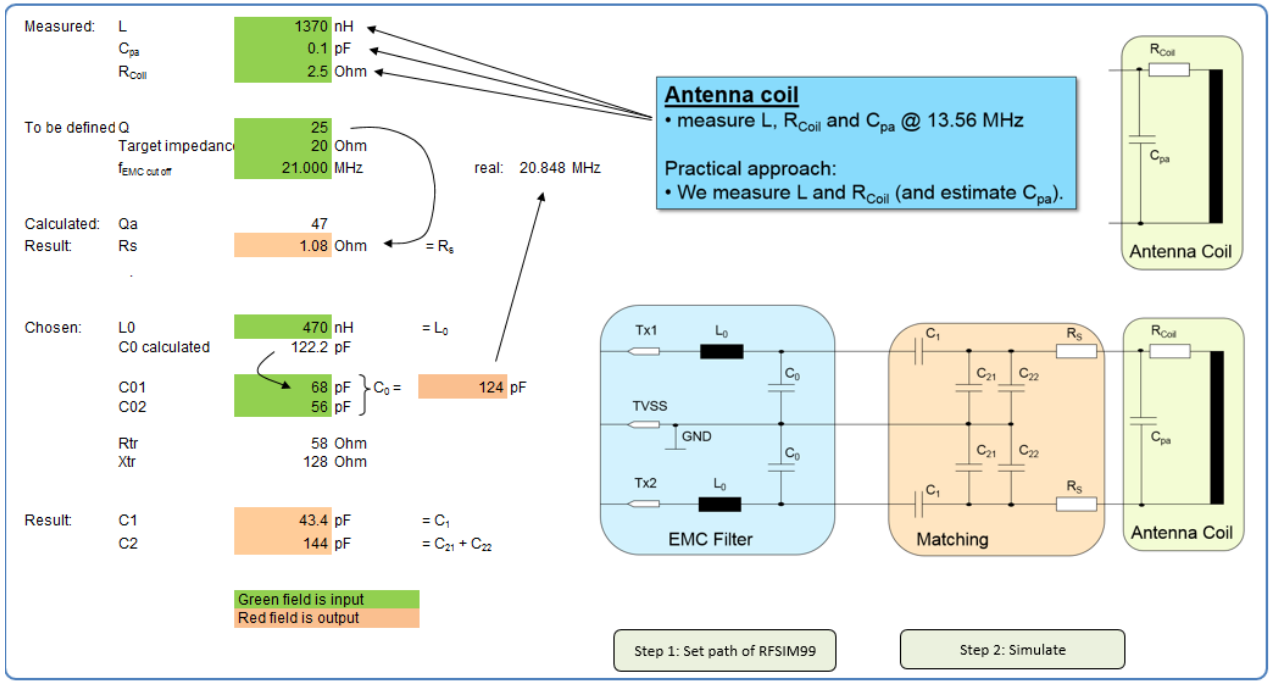

Input values to the calculation sheet:

$f_c = 21\ MHz$ $Q = 25$

$L_a = 1.3\ \mu H$

$Ra = 2.5\ \Omega$

Output values from the calculation sheet:

$C_1 = 43.4\ pF$

$C_2 = 144\ pF$

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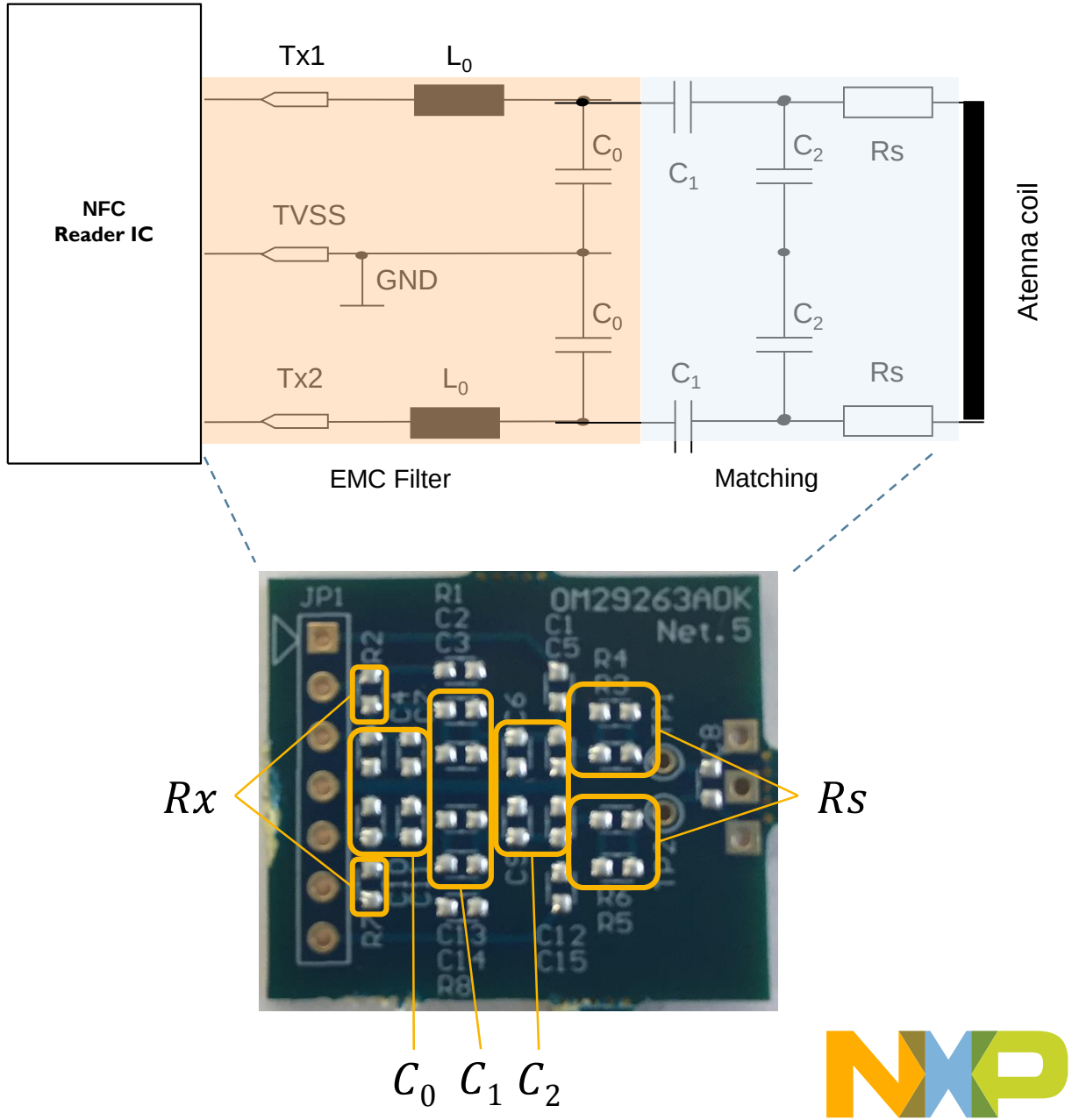

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Assembled commercial values in the first iteration:

$L_0 = 470\Omega$

$C_{11} = 39pF\ ; C_{12} = 4.7pF$

$C_0 = 120\ pF$

$C_{21} = 130\ pF\ ;\ C_{22} = 15pF$

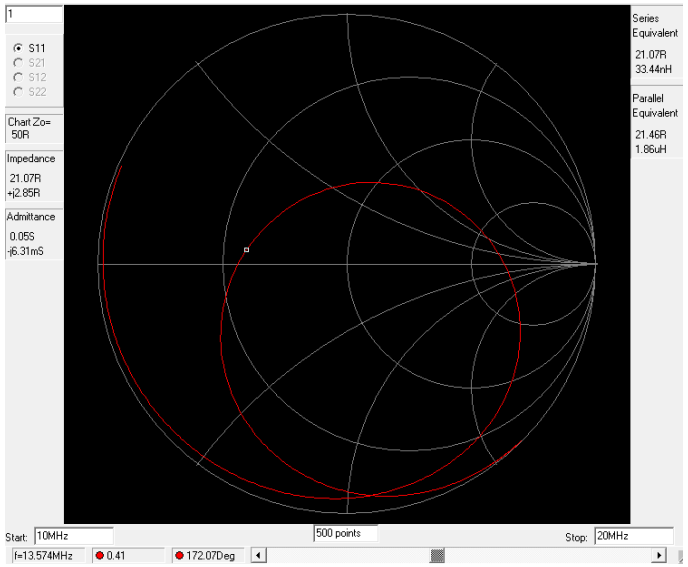

Fig. Simulation

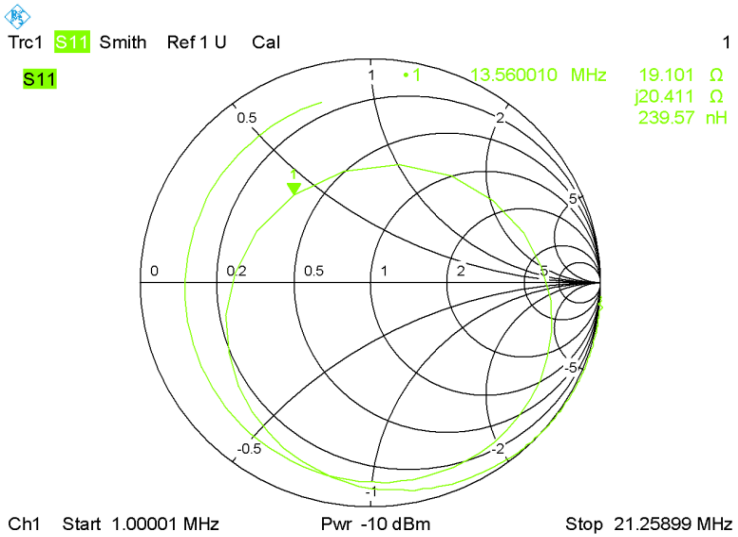

Fig. Field measurement

Training Mobile Knowledge

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Initial assembled values

$L_0 = 470nH$

$C_0 = 120\ pF$

$C_{11} = 39pF$
$C_{12} = 4.7pF$

$C_{21} = 130\ pF$
$C_{22} = 15pF$

Adjustment after field measurement iteration

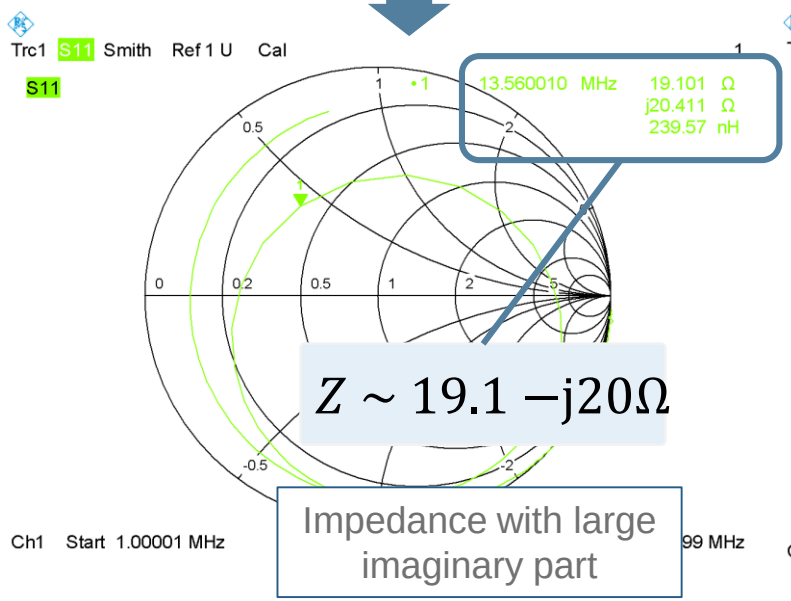
Final assembled values

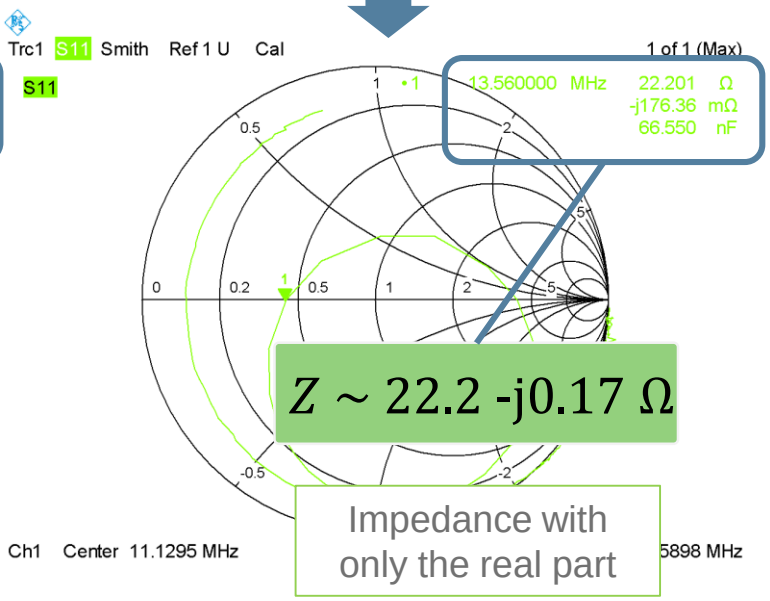
$L_0 = 470nH$

$C_0 = 120\ pF$

$C_{11} = 33pF$
$C_{12} = 3pF$

$C_{21} = 150\ pF$
$C_{22} = 4pF$





Training Mobile Knowledge

NFC antenna tuning steps

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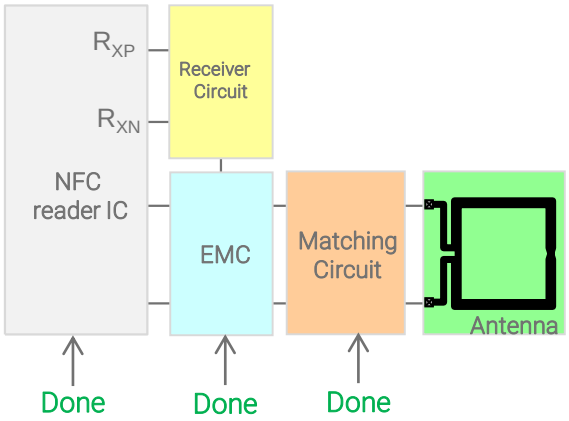
Antenna + matching circuit = resonance circuit



Goal:

- The voltage level at R_{xN} and R_{xP} pins must be high enough to achieve a good sensitivity, but must not exceed the given limit.
- Recommended circuit has a resistor and a capacitor in series. Typically the serial resistor R_{rx} is in the range of 7…15kΩ.

Procedure (for CLRC663 *plus*):

- Start with 11kΩ value and adjust sensitivity according to measurements.
- Measure voltage at Rx pin with a low capacitance probe (<2pF)
  - If URx > 1,7 Vpp → increase Rx
  - If URx < 1 Vpp → decrease Rx

Training Mobile Knowledge

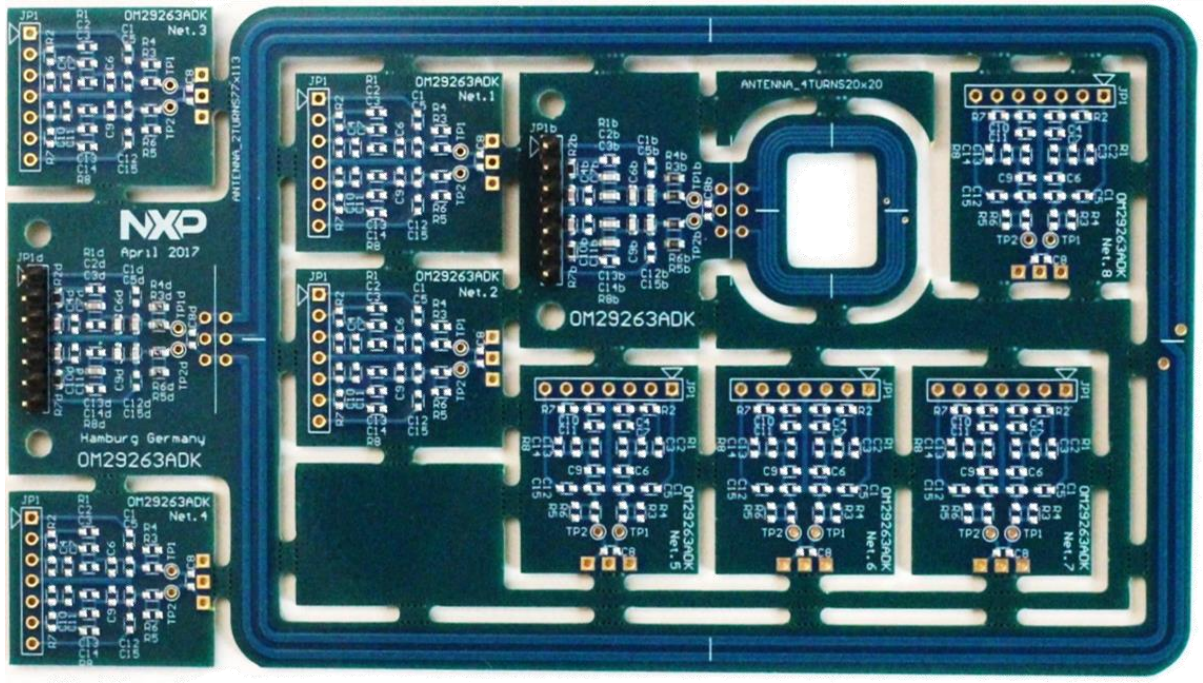
NFC antenna tuning additional information

NXP has prepared specific antenna design recorded webinars (and respective presentation slides) which can be found in following links:

Webinar title	Agenda	Recorded webinar
Which Antenna for what purpose?	• What is the best antenna size & form? • Major design parameters • Layout & design tips	Recorded webinar
Antenna matching	• What does „matching“ mean? • What are the required simulation tools? • What are the required measurement tools?	Recorded webinar
Metal environment	• How does metal environment influence the antenna? • How to use ferrite? • Generic guidelines regarding meta	Recorded webinar
Optimization & debugging	• How can I optimize the performance? • Relevant test signals & registers • Major test & debug setup	Recorded webinar
Test & Qualification	• Which reader antenna tests are required? • What are the required test tools? • Major tests	Recorded webinar
EMC related design	• What are the key influences related to EMC? • Where does EMC have major impact on reader design?	Recorded webinar

Using OM29263ADK kit to evaluate the performance of different antenna shapes

OM29263ADK NFC Antenna Development Kit



Part number complete kit: OM29263ADK
12NC: 935361598598
Ordering: eCommerce

OM29263ADK can be:

- Directly connected to the CLEV6630A or the CLEV6630B development board
- Tuned to connect to the PNEV5180B or the PNEV7462C development board
- Used to connect and tune any antenna coil to any of the NFC reader evaluation boards

OM29263ADK is the perfect tool for:

- **Evaluating the performance of different antenna shapes**
- **Prototyping your antenna design quickly**

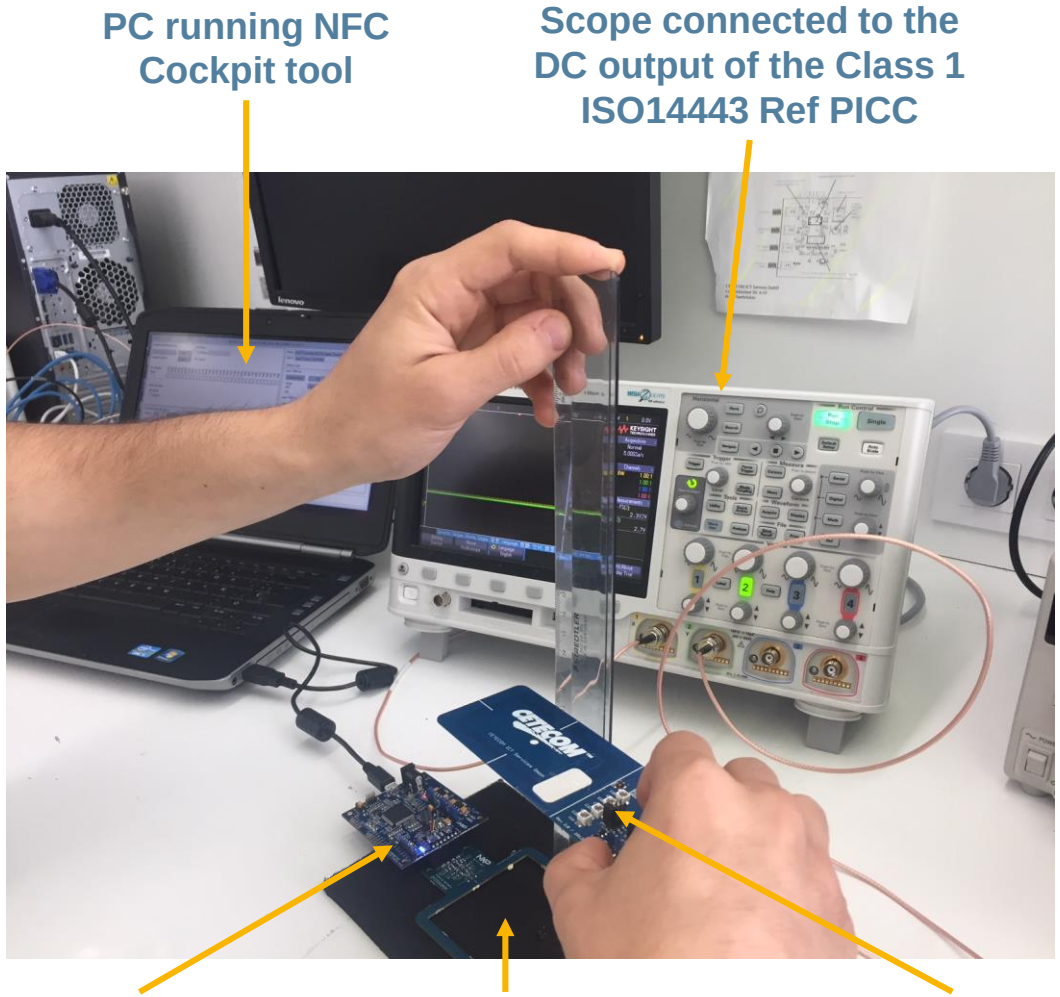
Now

Training Mobile Knowledge

Setup scenario

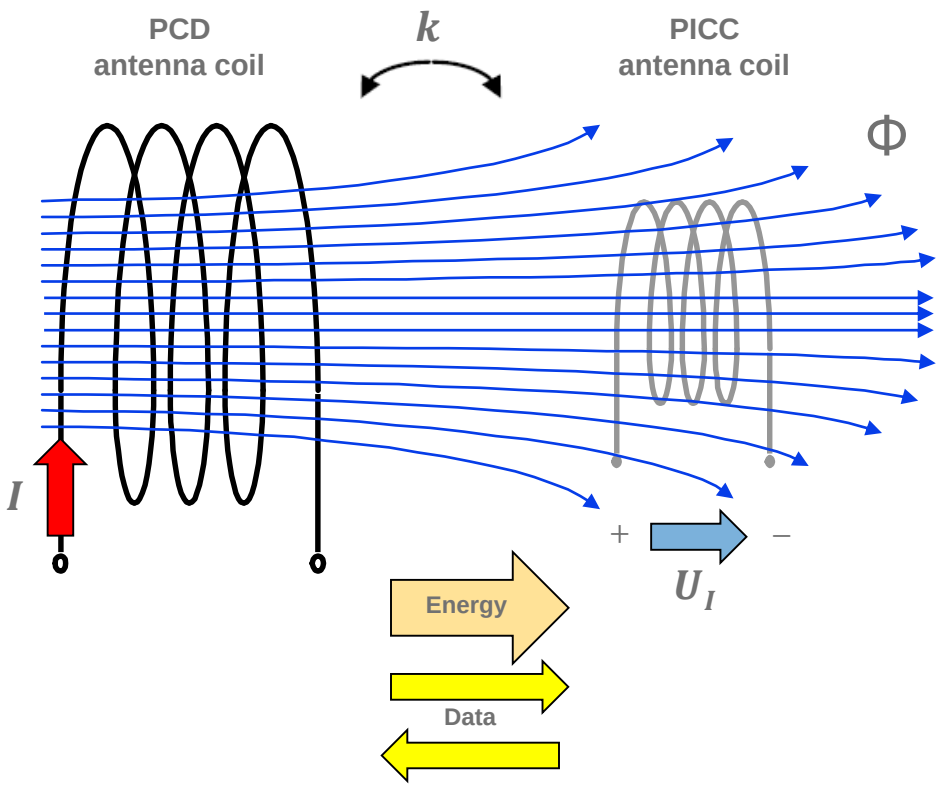
- **Goal**: Measure with a ISO14443 Ref PICC how the picked-up voltage drops with distance:
  - Using 77x113mm2 antenna included in OM29263ADK
  - Using 20x20 mm2 antenna included in OM29263ADK
- Steps:
  - Tune the two antenna matchings to Z~ 20.
  - Use NFC Cockpit to turn on RF field
  - Take measurements of the Class 1 Ref PICC DC output (Volts) as we increase the distance.

This lab exercise is shown only for illustrative purposes to show how OM29263ADK kit can be used to evaluate the performance of different antenna shapes

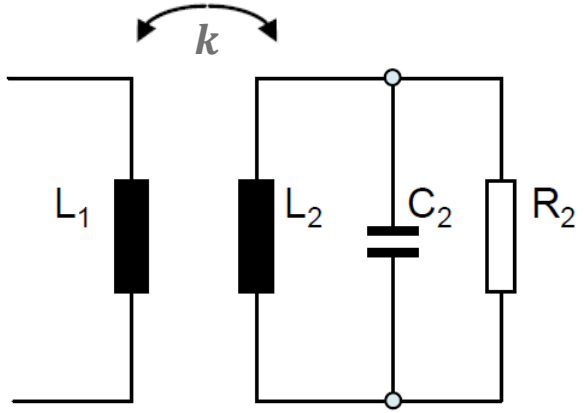


Some context about NFC antenna performance

Coupling coefficient



- The coupling coefficient depends on:
  - The geometric dimensions of both conductor loops.
  - The position of the conductor loops in relation to each other
  - The magnetic properties of the medium (μ_0)



$$0 < k < 1$$

k =1 → total coupling

k =0 → full decoupling

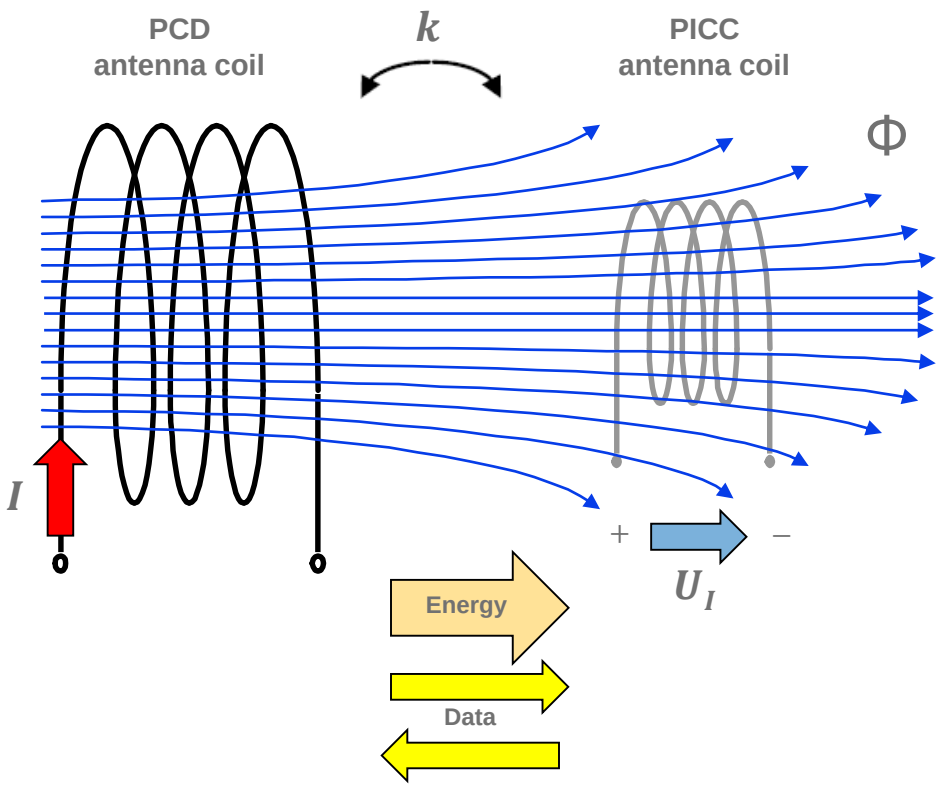
$$k = \mu_0 \cdot \frac{r^2}{2\sqrt{(r^2+x^2)^3}} \cdot \frac{A_2}{\sqrt{L_{01} \cdot L_{02}}}$$

Permeability constant | *Geometrical quantity* | *"Fixed"*

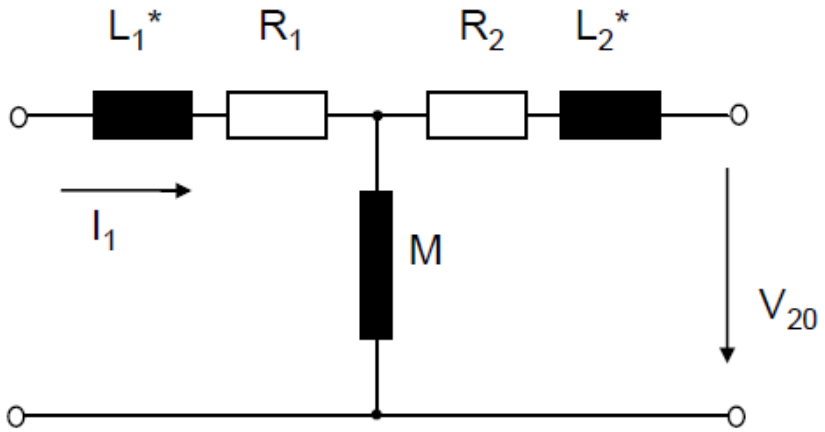
Training Mobile Knowledge

Some context about NFC antenna performance

Mutual inductance



- The mutual inductance allows us to determine the voltage induced in the PICC antenna.
- This is a function of the coupling coefficient and the current provided in the reader antenna.



$$M = k \cdot \sqrt{L_1 \cdot L_2}$$

$$V_{20} = \omega \cdot M \cdot I_1$$

The larger the coupling factor, the larger the card voltage.

Training Mobile Knowledge

Antenna tuning components used for the large antenna

1. Define target impedance and Q-factor
   To optimize RF output power or battery life
2. Measure antenna coil
   Characterize R,L,C antenna coil parameters
3. Design EMC Filter
   Filtering unwanted harmonics
4. Calculate matching circuit components
   Use NXP antenna design tools
5. Assemble & measure
   Impedance measurement in the field
6. Fine tune matching components
   Simulation and matching adjustment according to measurements in the field
7. Adjust receiver circuit
   Tune receiver sensitivity

$Z \sim 19\ \Omega$ $Q \sim 10$

$L_a \sim 1260\ nH$ $C_a \sim 0.1\ pF$ $R_a \sim 2.9\ \Omega$

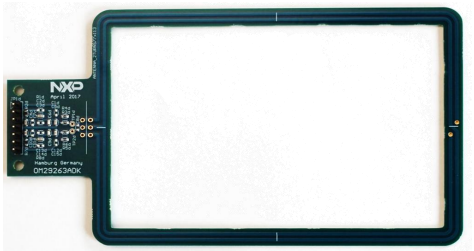
$f_c = 21\ MHz$ $L_0 = 470\Omega$ $C_0 = 120\ pF$

$C_{11} = 56\ pF\ ;\ C_{12} = 6pF$

$C_{21} = 120\ pF\ ; C_{22} = 4\ pF$

$Rx = 33\ k\Omega$

$Rs = 3.8\ \Omega$



The select Q-factor allows us to accommodate ISO/IEC14443 higher bitrates (212kbps, 424kbps, 848kbps)

Training Mobile Knowledge

Antenna tuning components used for the small antenna

1. Define target impedance and Q-factor
   To optimize RF output power or battery life
2. Measure antenna coil
   Characterize R,L,C antenna coil parameters
3. Design EMC Filter
   Filtering unwanted harmonics
4. Calculate matching circuit components
   Use NXP antenna design tools
5. Assemble & measure
   Impedance measurement in the field
6. Fine tune matching components
   Simulation and matching adjustment according to measurements in the field
7. Adjust receiver circuit
   Tune receiver sensitivity

$Z \sim 20\ \Omega$ $Q \sim 10$

$L_a \sim 557nH$ $C_a \sim 0.1pF$ $R_a \sim 1.5\ \Omega$

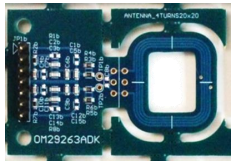
$f_c = 21\ MHz$ $L_0 = 470\Omega$ $C_0 = 120\ pF$

$C_{11} = 47\ pF\ ;\ C_{12} = 5pF$

$C_{21} = 300\ pF\ ; C_{22} = 67\ pF$

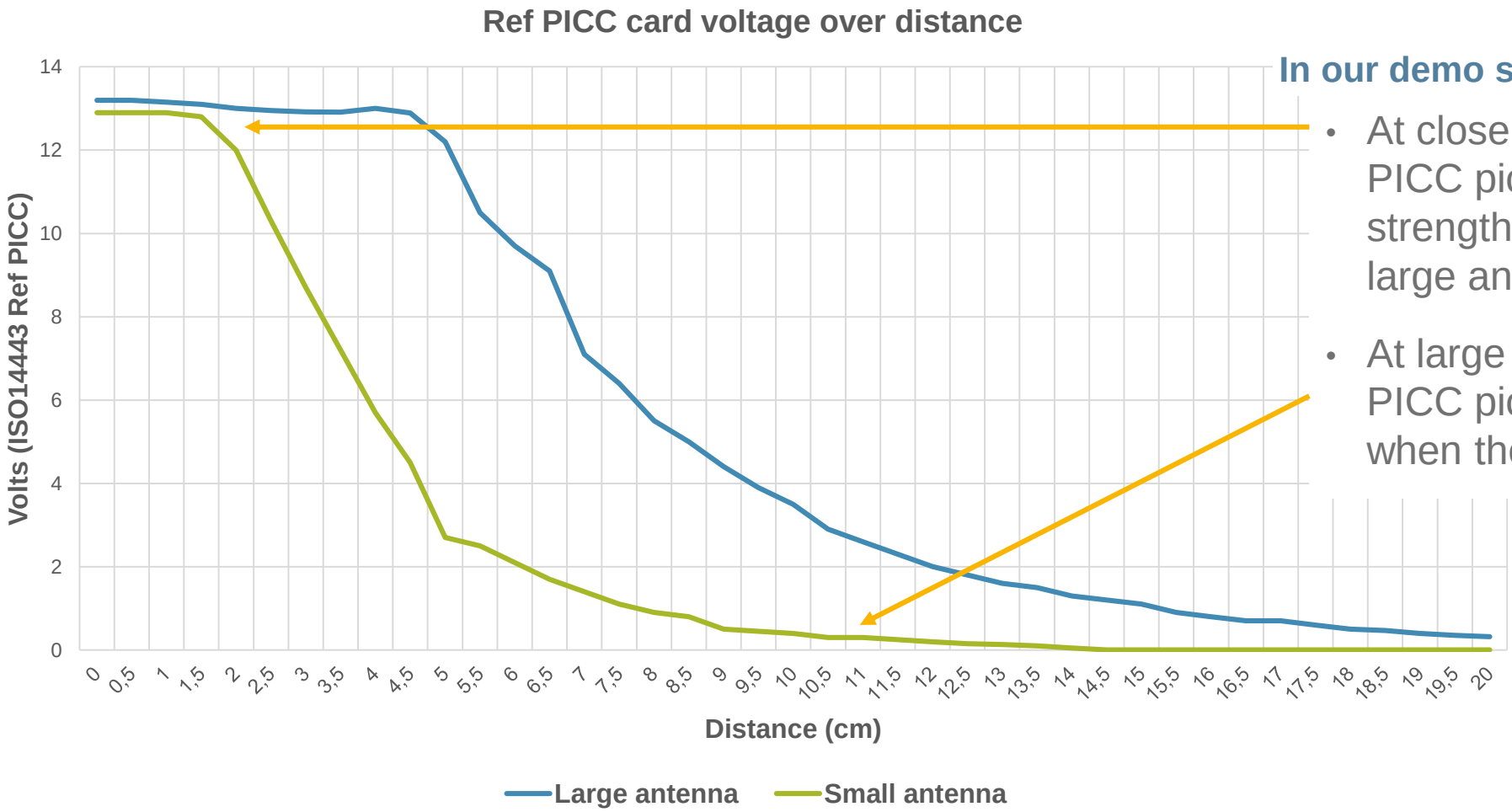
$Rx = 11\ k\Omega$

$Rs = 0.5\ \Omega$



Training Mobile Knowledge

OM29263ADK large antenna vs small antenna



In our demo setup:

- At close distance, the Class 1 Ref PICC picks-up the same field strength level for both the small and large antenna
- At large distance, the Class 1 Ref PICC picked-up voltage drops earlier when the small antenna was used

As an approximation:

Small size = small operating distance
Large size = larger operation distance

Training Mobile Knowledge

ISO/IEC14443 vs ISO/IEC15693 reader

Quality factor

As ISO/IEC14443 and ISO/IEC15693 transmission pulses are different, Q-factor can be optimized for each protocol.

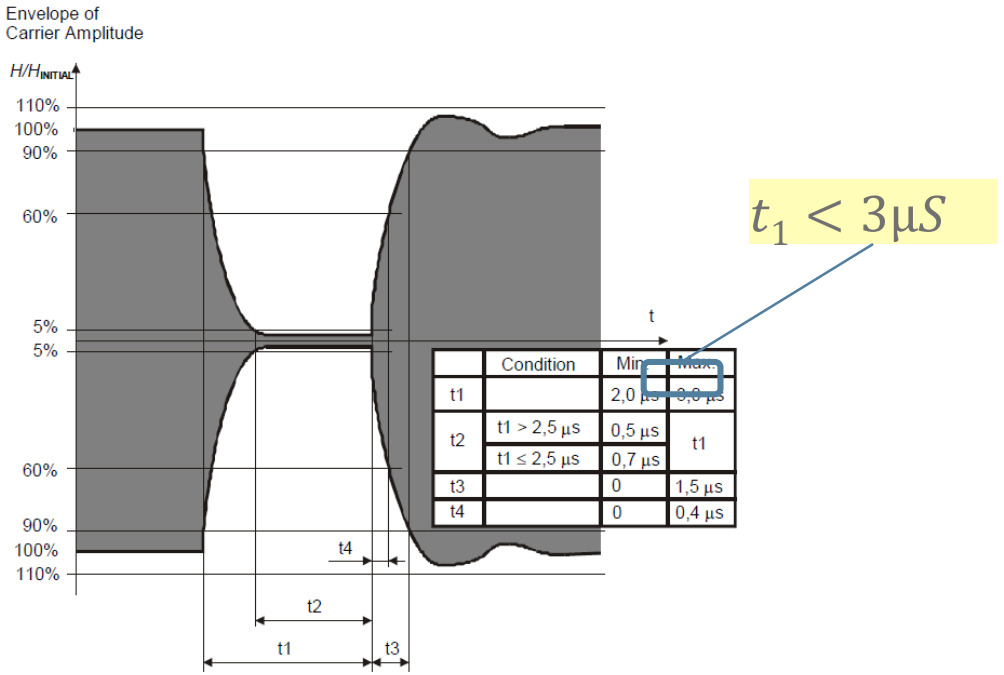


Fig 1. Envelope of a transmitted ISO14443 pulse shape

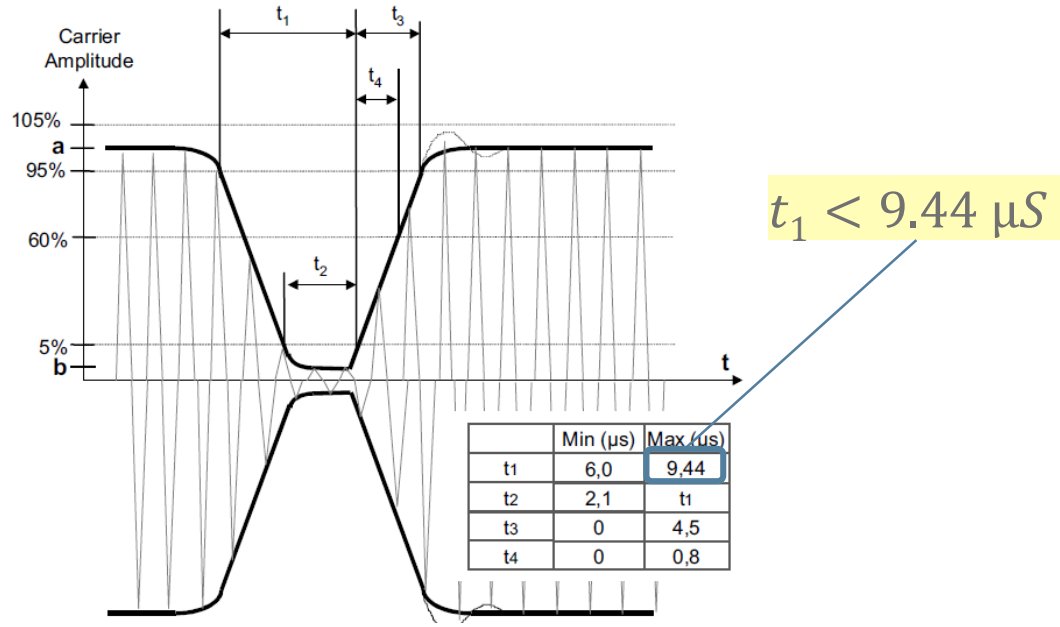


Fig 2. Envelope of a transmitted ISO15693 pulse shape

ISO/EC15693 allows a higher Q factor due to the lower bandwidth requirement and more relaxed pulse shape timings

Training Mobile Knowledge

ISO/IEC14443 vs ISO/IEC15693 reader

Quality factor

Data transmission bandwidth:

- Can be calculated with:

$$B = \frac{f}{Q} \quad \Rightarrow \quad Q = f \cdot T$$

ISO14443 quality factor

- Can be calculated with:

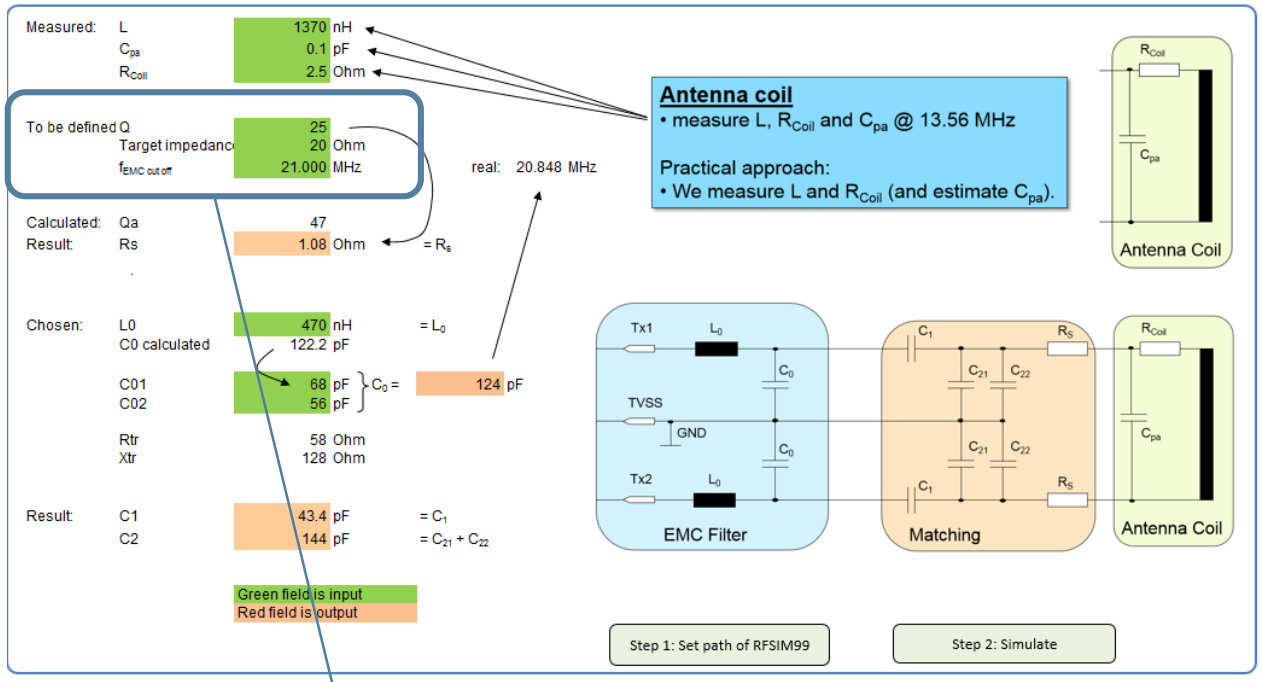
$$Q < f \cdot T$$

$$Q < 13.56MHz \cdot 3\mu S \quad \Rightarrow \quad Q < 30$$

ISO15693 quality factor

- Can be calculated with:

$$Q < 13.56MHz \cdot 9.44\mu S \quad \Rightarrow \quad Q < 100$$



Use our Excel sheet to adjust the Q-factor desired for your system !

Training Mobile Knowledge

Closure

Further information

- Discover NFC Everywhere: https://www.nxp.com/nfc
- Get your technical NFC questions answered: https://community.nxp.com/community/identification-security/nfc
- List of Approved Engineering Consultants (AEC) for NFC: https://nxp.surl.ms/NFC_AEC
- Recorded NFC trainings: http://www.nxp.com/support/online-academy/nfc-webinars:NFC-WEBINARS

Design your NFC Antenna with NXP's OM29263ADK dev. kit

Thank you for your kind attention!

Please remember to fill out our **evaluation survey** (pop-up)

Check your email for **material download** and on-demand **video** addresses

Please check NXP and MobileKnowledge websites for **upcoming webinars** and **training sessions**

http://www.nxp.com/support/classroom-training-events:CLASSROOM-TRAINING-EVENTS

www.themobileknowledge.com/content/knowledge-catalog-0

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