Training Mobile Knowledge

PN5180 – The best full NFC frontend on the market

Public

MobileKnowledge
January 2016

Agenda

Session 13th January: *PN5180 Introduction*

- Positioning within the NFC portfolio and overview
- Target markets and benefits
- Product description and key features, including the outstanding Dynamic Power Control
- PN5180 design tools, documentation and ordering details

Session 27th January: *PN5180 product support package*

- PN5180 development board introduction
- PNEV5180B SW installation
- PN5180 NFC Cockpit application
- PN5180 SW development environment
- NFC Reader Library and available SW examples

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NXP Training Mobile Knowledge

Product positioning and overview

PN5180 within the NFC product portfolio

Connected NFC Tag solutions

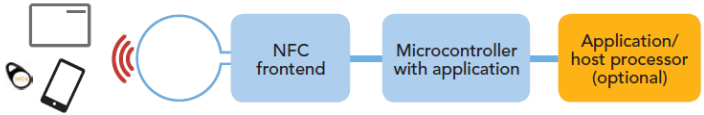
The fastest, most BoM optimized way to add NFC to a system.

***Products**: NTAG21xF , NTAG I2C*

NFC frontend solutions

The most flexible way to add NFC to a system.

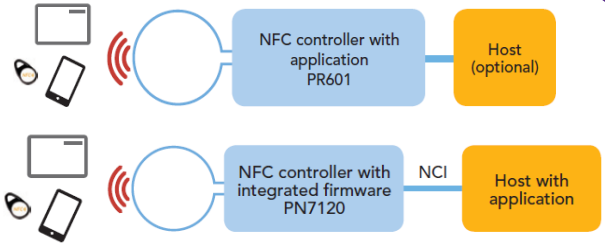
Products**: MFRC522, MFRC523, PN512, CLRC663, **PN5180



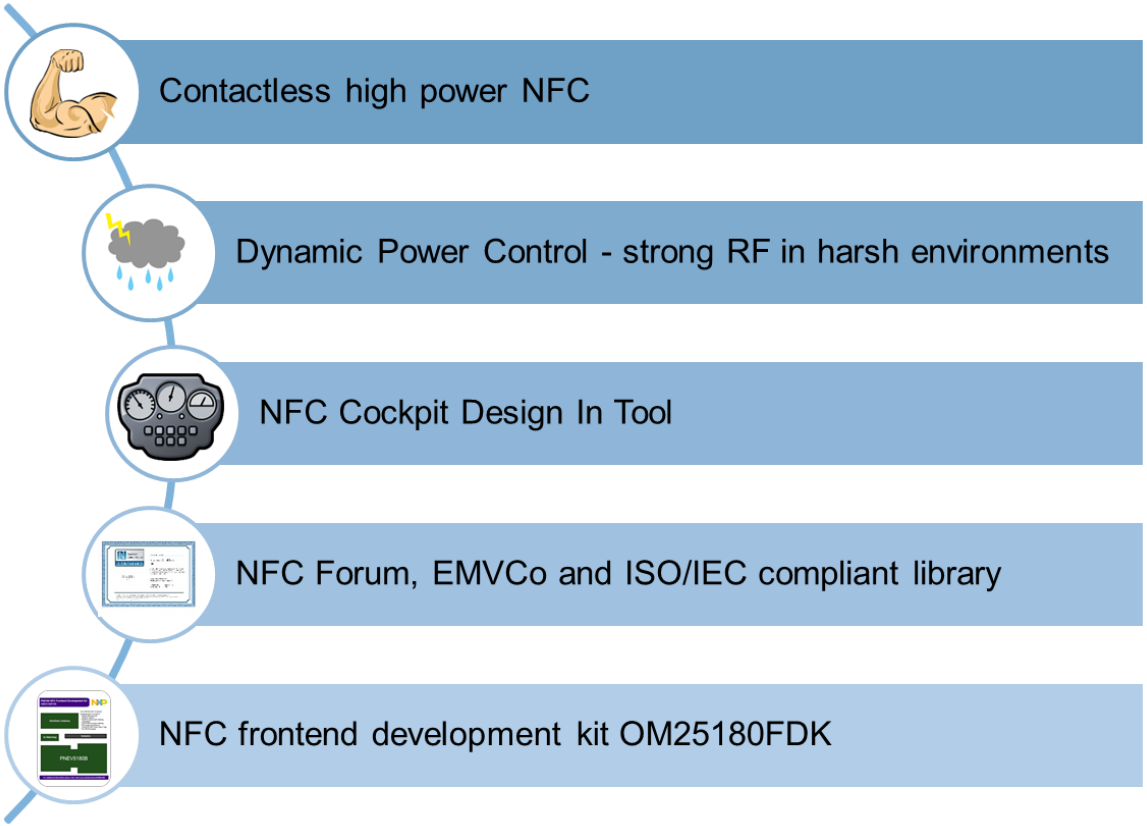
NFC controller solutions

Combination of NFC frontend with an advanced 32-bit microcontroller.
Options include integrated firmware or freely programmable microcontroller.

***Products**: PR601, PN533, PN7120*



PN5180 is the best full NFC frontend in the market



PN5180 technical product features

Characteristics

- RF driver current up to 250mA
- Dynamic Power Control DPC
- Adaptive modulation waveform control
- RF driver supply voltage: 2,7V…5.5V
- Host interface: 1,8V or 3.3V
- Flexible low power card detection
- 4 Multi purpose Outputs‘s (only on TFBGA)
- HW support for EMVCo EMD handling
- 13.56 MHz RF clock generation from external 8, 12, 16 and 24 MHz source
- Overheat protection
- Operating temperature range: -30…+85°C

Interface to Host

- SPI up to 7Mbit/s
- IRQ and BUSY signal for improved host communication

Supported RF protocols

- Reader/Writer mode
- ISO/IEC 14443 A&B R/W support up to 848 kbit/s
- FeliCa R/W support
- R/W support for MIFARE 1K, 4K
- NFC Forum tag type 1,2,3,4,5 reader
- ISO/IEC15693 reader (I-Code SLI)
- ISO/IEC 18000-3M3 reader (I-Code ILT)
- EMVCo 2.3.1 and 2.5 compliance (L1)
- Peer to Peer mode
- Passive-Initiator / Passive-Target
- Active-Initiator / Active-Target
- P2P supported for types: A (106 kbit/s), F (212,424 kbit/s)
- Card Emulation
- ISO/IEC 14443A (up to 848 kbit/s)
- Active Load Modulation

Packages

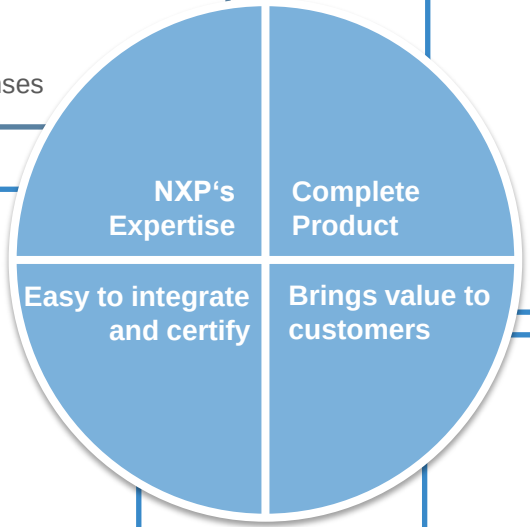
- HVQFN40 and TFBGA64
- Part removal detection (PRD, only on TFBGA)

Benefits and target markets

PN5180 main benefits in a nutshell

- Market leader in Contactless & Contact interfaces
- Creator of NFC & MIFARE technology
- Proven expert in EMVL1 software stack
- Standardizing member of ISO14443 A&B licenses

- Several features, like DPC, EMD eases EMVCo and NFC reader certification
- Libraries for **EMVCo, NFC Forum, MIFARE card family** compliance
- The EMVCo L1 (analog and digital) library in source code makes it easier to add ICs in designs
- BGA package provides facilities for PCI certification



- PN5180 is the best full NFC frontend IC on the market
- Strong RF efficiency in difficult environments using DPC feature
- Low power card detection technology
- Power saving feature with robust operation
- Integrated support for EMVCo EMD handling
- Fast SPI host interface with optimized commands for use with 32-bit host controllers

- Easier RF tuning due to DPC and NFC Cockpit tool simplifying integration
- Flexibility of a frontend allowing customization
- Easier certification with BGA package

Targeted markets & customer benefits

PAYMENT, POS & mPOS TERMINALS

Benefits

- **Full NFC** allows interaction with mobile phones
- **High RF output power** reduces Bill of Material and antenna cost
- **Dynamic power control** simplifies operation in harsh environment
- **TFBGA package** eases PCI certification
- **EMVCO L1 compliant library** reduces design in cycles

PHYSICAL ACCESS CONTROL

Benefits

- **Full NFC** allows interaction with mobile phones
- **Multi Card protocol** supports any card reading
- **Dynamic power control** simplifies operation in harsh environment
- **Low power card detection** extends battery life

INDUSTRIAL AND eGOV

Benefits

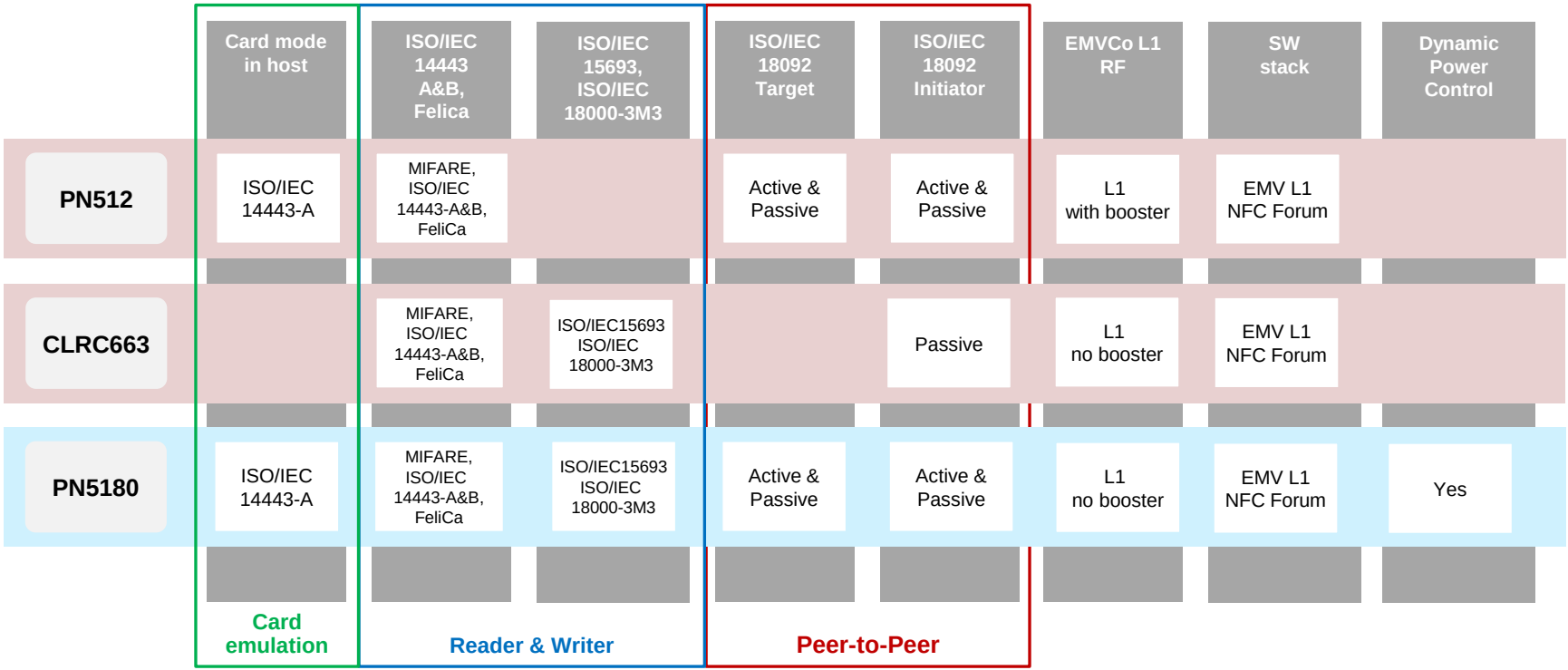
- **High RF output power** for reliable operation and operating volume
- **Dynamic power control** simplifies operation in harsh environment e.g. scanners
- **Integrated EMD handling** for robust communication links
- **Vicinity card standards** support for industrial applications
- **ISO/IEC 14443 compliant library** reduces design in cycles

Key benefits per market

	Payment	Access	Industrial
Best RF performance	✓	✓	✓
Eases PCI compliancy	✓		
Full NFC & contactless interoperability	✓	✓	✓
Supports standards and proprietary implementations	✓	✓	✓
Active load modulation in card mode		✓	✓
Long battery lifetime		✓	✓
Fast time-to-market	✓	✓	✓

PN5180 positioning versus other NFC frontends

Positioning PN5180 vs other NXP NFC frontends

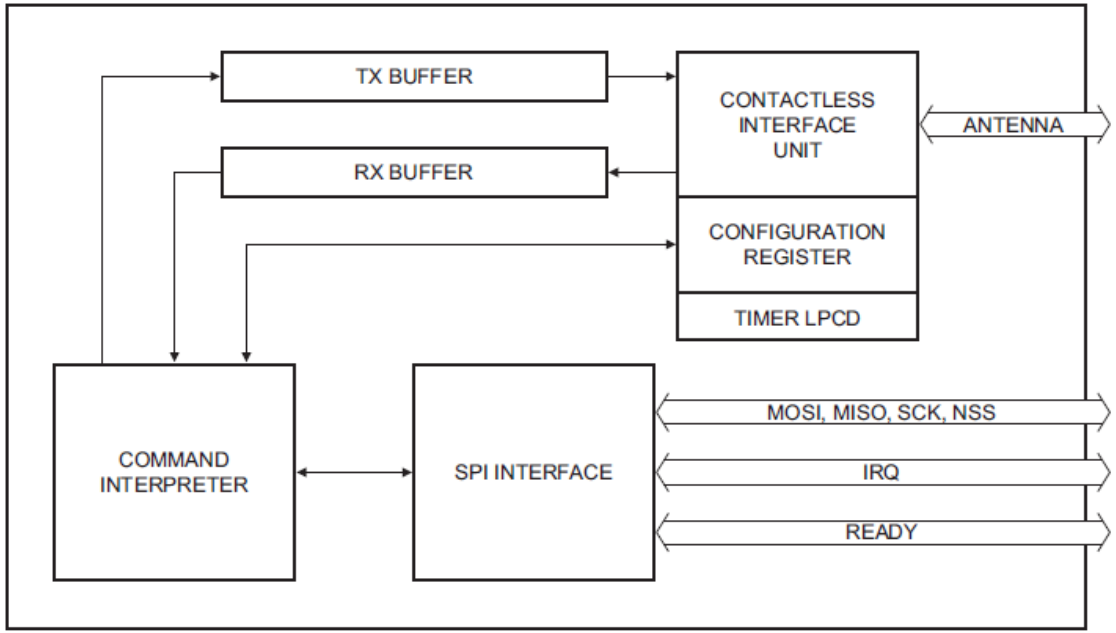


Positioning PN5180 vs other NXP NFC frontends

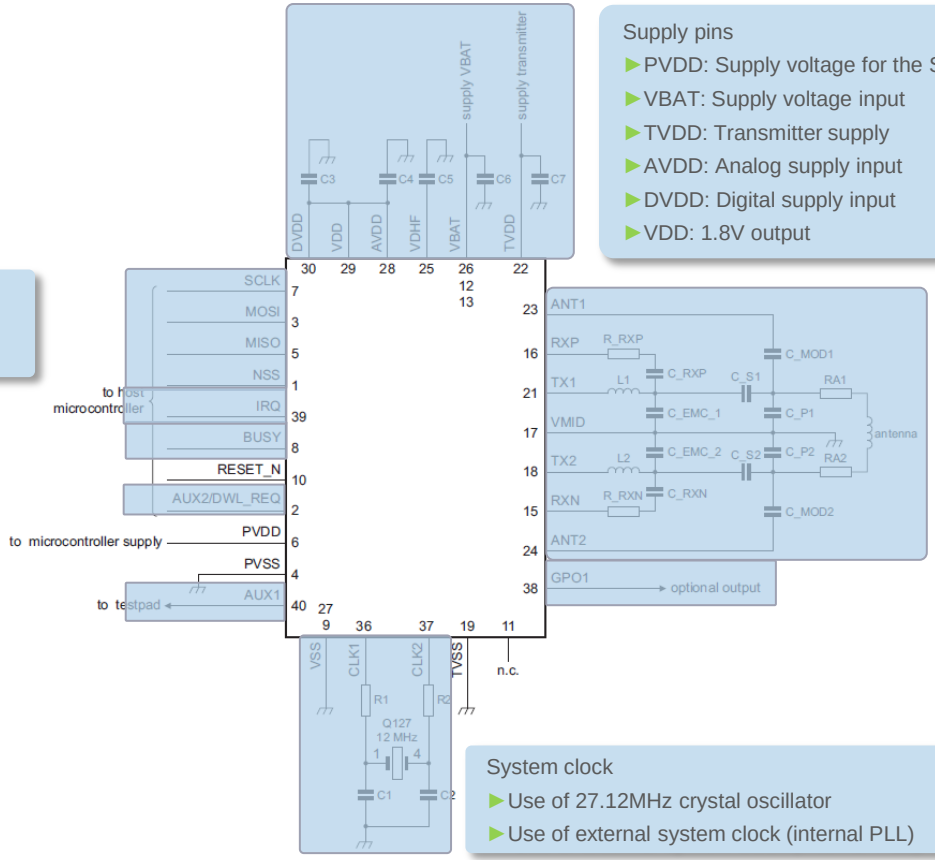
Feature	PN512	CLRC663	PN5180	Comment
BGA package	YES	NO	YES	Suitable for payments
BGA package with anti grinding	NO	NO	YES	Advantage for PCI certification (anti-probing protection)
Additional output pins to drive LEDs	NO	NO	YES	Saves IOs on host controller
Max. operating transmitter current	100mA	250mA	250mA with Dynamic Power Control	Dynamic Power Control allows to benefit at a best from the available 250mA on the PN5180
PLL & System clock	NO	YES, output	YES, input	Can save cost (XTAL) on the system BOM (RC663) or reuse existing system frequency (PN5180)
Low power card detection	NO	YES	YES	
Complete set of field proven libraries for embedded systems	Full NFC, Reader & EMVCo	Reader & EMVCo	Reader, Full NFC & EMVCo	
Improved waveform robustness versus antenna detuning	NO	YES	YES with adaptive modulation waveform control	Increased stability compared to PN512 and CLRC663
Receiver structure	Single ended input	Differential input	Differential input with dynamic range control	Differential receiver is more sensitive and more robust in case of external noise

Block and application diagram

Block diagram



Application diagram



Supply pins
- ▶PVDD: Supply voltage for the SPI interface
- ▶VBAT: Supply voltage input
- ▶TVDD: Transmitter supply
- ▶AVDD: Analog supply input
- ▶DVDD: Digital supply input
- ▶VDD: 1.8V output

SPI interface up to 7Mbps
- ▶Half duplex data transfer
- ▶Extended by a BUSY signal line

RF communication
- ▶ANT1,ANT2: Antenna connection for card emulation mode
- ▶RXP,RXN: Receiver input
- ▶TX1,TX2: Antenna driver output

Debug signal output config:
- ▶Analog debug signals: AUX2, BUSY
- ▶Digital debug signals: IRQ, GPO,AUX2,AUX1

GPO
- ▶Configurable digital output (e.g can be used to drive a status LED).
- ▶Controlled by host commands

Temperature sensor:
- ▶In case sensed device temperature is higher than configured, a IRQ is raised to the host to react

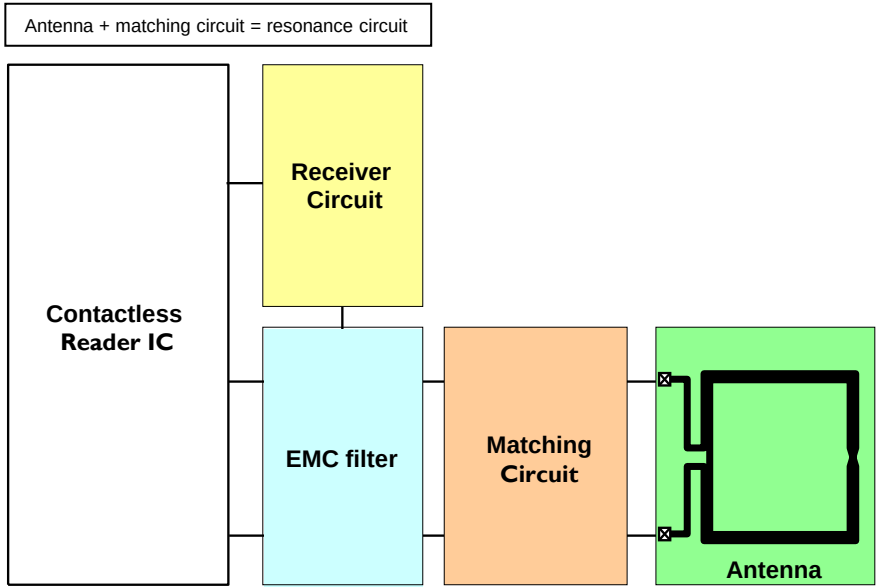
System clock
- ▶Use of 27.12MHz crystal oscillator
- ▶Use of external system clock (internal PLL)

Antenna design for PN5180

“Symmetric” and “Asymmetric” antenna tuning

NFC antenna tuning procedure

1. Define target impedance
   To optimize RF output power or battery life
2. EMC filter design
   Filtering of unwanted harmonics
3. Measure antenna coil
   Determine LCR values of the antenna coil
4. Adjust Q-factor
   With damping resistor if needed
5. Calculate matching components
   Using provided excel sheet
6. Fine tuning
   Simulation and field measurement
7. Adjust receiver circuit
   Tuning reader sensitivity

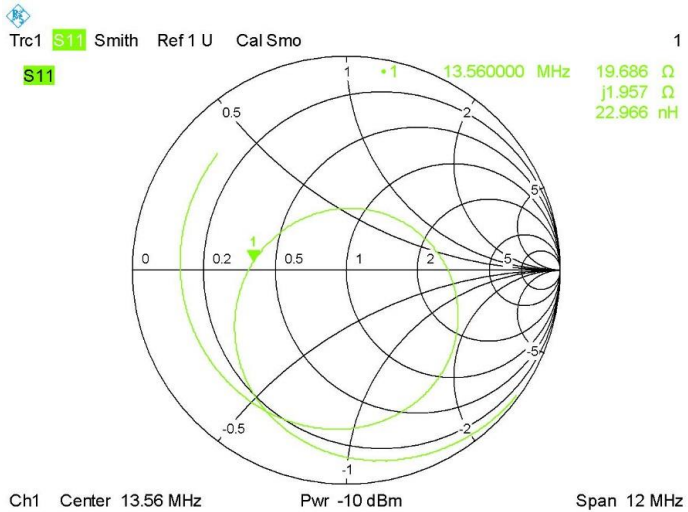


NFC antenna tuning
Naming convention

“Asymmetric“ antenna design (e.g. CLRC663)

Automatically limits the current and field strength under loading / detuning

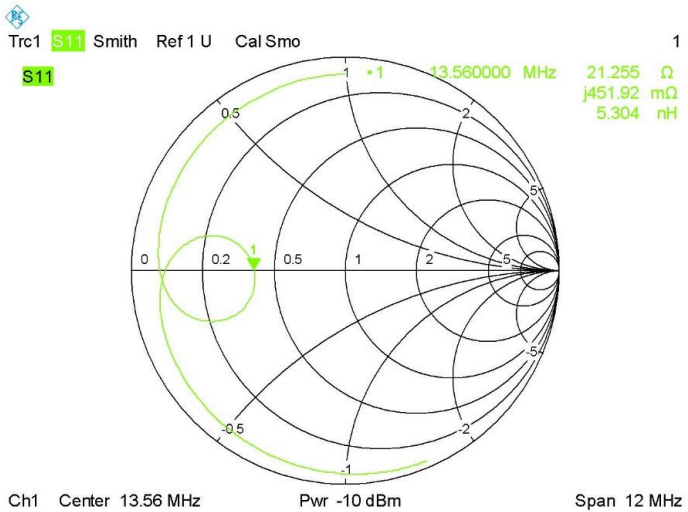
Not optimum transfer function



“Symmetric“ antenna design (new for e.g. PN5180)

Provides more power transfer and better transfer function

Requires current / field strength limiter



Current / field strength control is required in “symmetric” antenna design

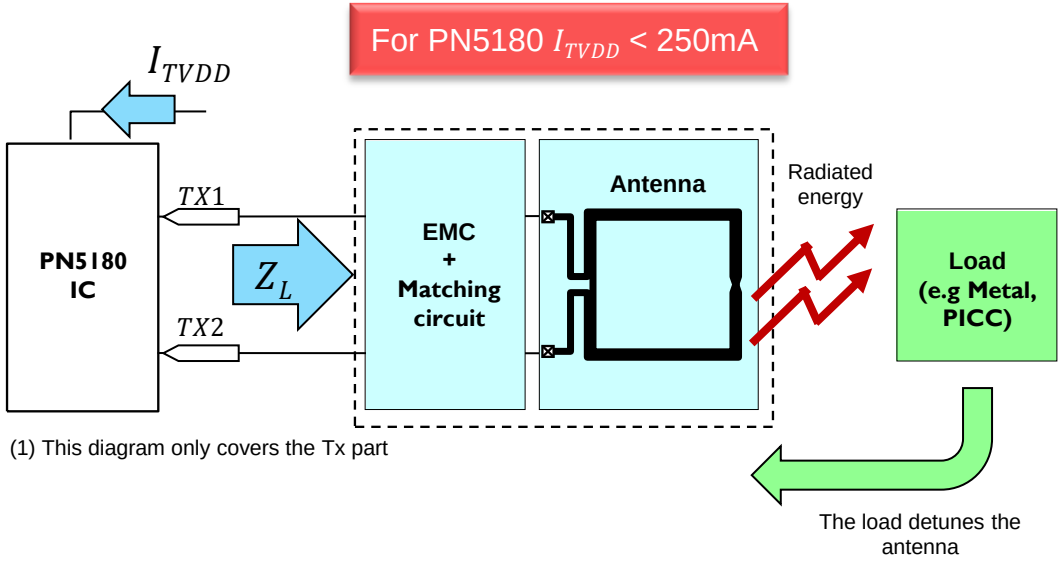
NFC antenna tuning

Define target impedance so that I_{TVDD} does not exceed the IC limits (Step 1)

- We need to adjust the target impedance the NFC reader IC “sees” according to the performance we want to achieve.
  - Maximum output power
  - Minimum current consumption (battery life)
- The target impedance (R_L) is chosen so that the highest possible output power does not exceed the maximum driver current (I_{TVDD}).

R_L = 20 …… 80 Ω e.g PN5180

Maximum output power (Operating distance)	Minimum Current Consumption (Battery life)



Typical load detuning effect in “asymmetrical” antenna tuning

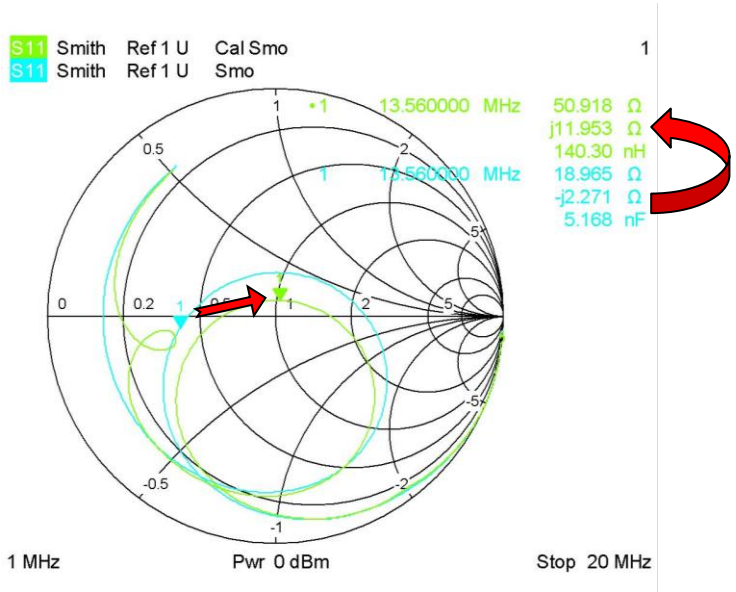


Fig. Loading with Reference PICC

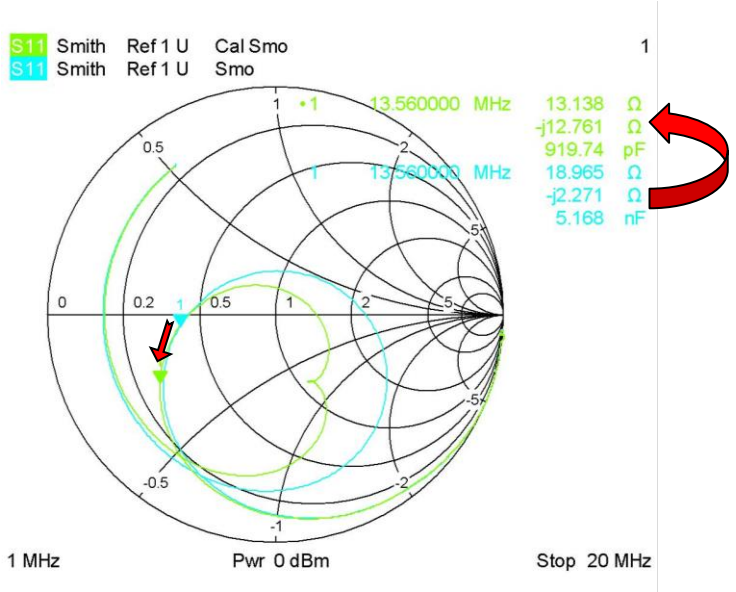
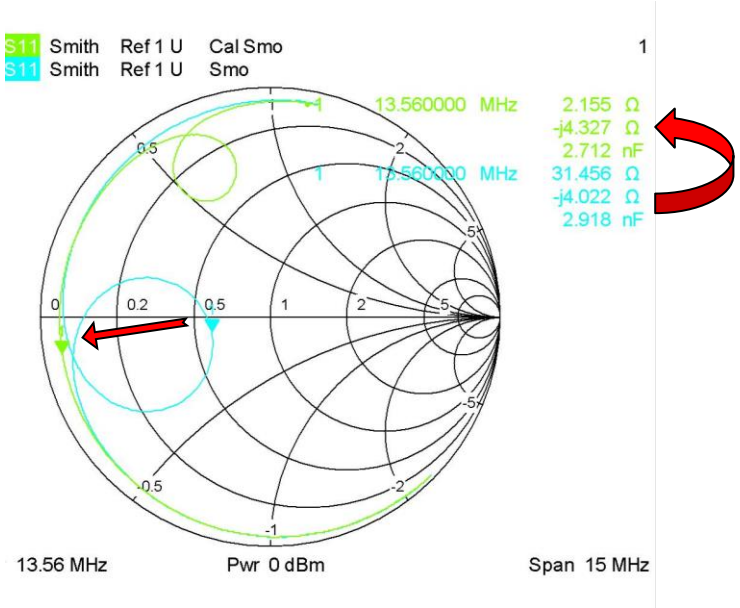


Fig. Loading with smartphone (metal)

The load increases → I_{TVDD} **and field strength is reduced**

The load decreases, but I_{TVDD} does **not** exceed the limit

Typical load detuning effect in “symmetrical” antenna tuning



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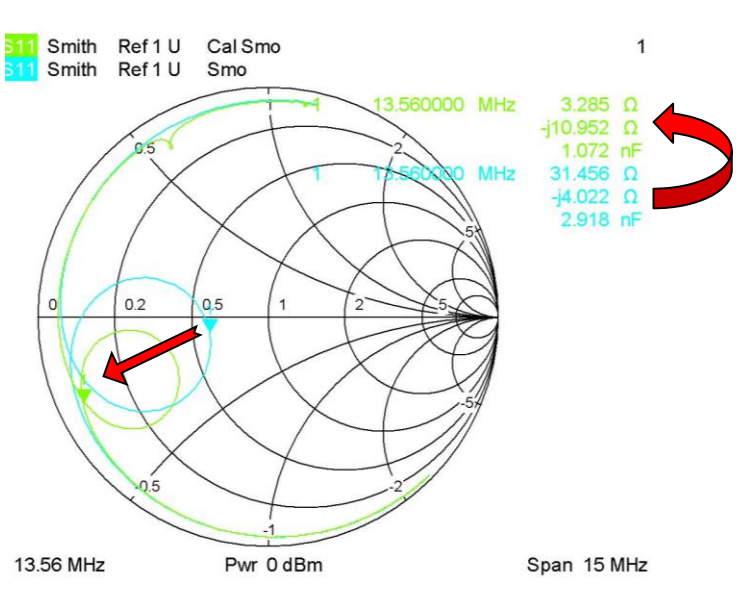


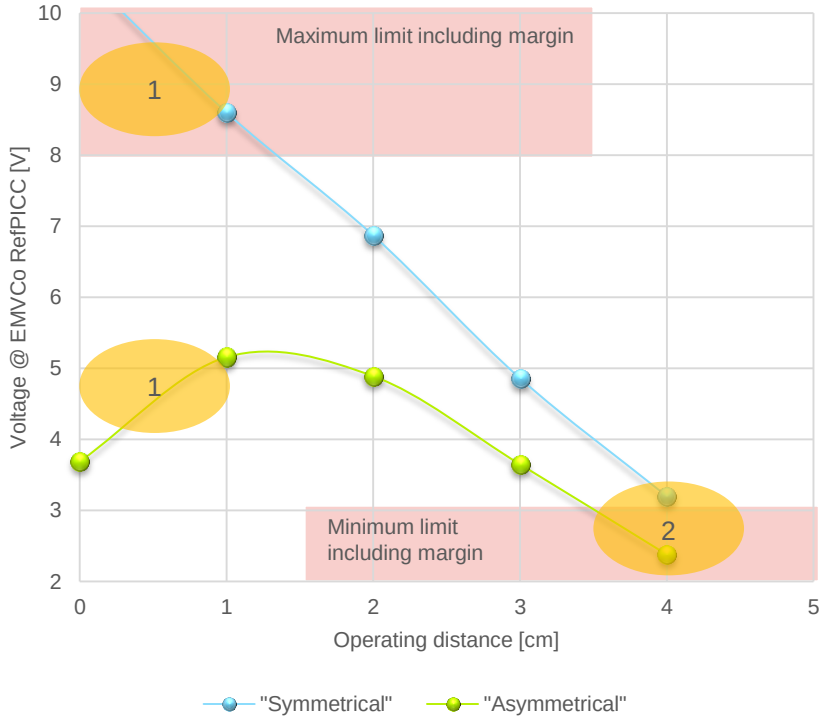
Fig. Loading with smartphone (metal)

The load decreases→ Increases power and I_{TVDD}
I_{TVDD} & field strength may exceed the limit !!!

Solution: Dynamic Power Control

“Asymmetrical” vs “symmetrical” small antenna tuning without DPC

Fig. EMVCo “asymmetrical and “symmetrical” tunings with small antenna



Behavior at short distance

1 **Asymmetric** antenna delivers enough field strength at close distance

1 **Symmetric** anntena at close distance (= strong coupling) the detuning to a lower impedance

- causes higher ITVDD.
- causes higher field strength.
- might kill the reader IC.
- might exceed ISO and EMVCo limits.

Behavior at large distance

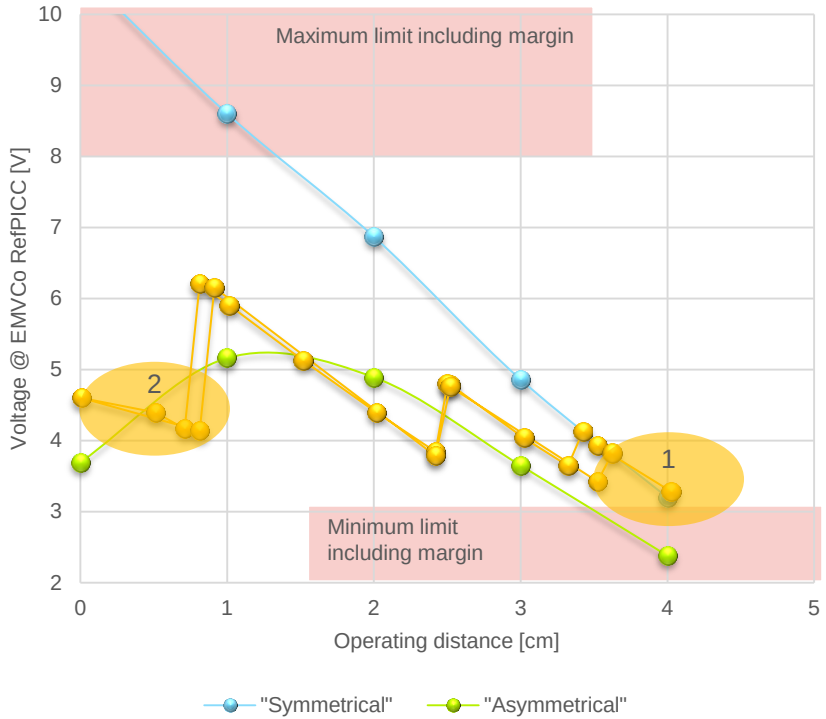
2 **Asymmetric** antenna does not deliver enough field strength at large distance

2 **Symmetric** antenna at large operating distance (= low coupling) the improved transfer function

- allows a higher Q-factor in the antenna coil circuit.
- improves the Tx shaping (options).
- improves the power transfer (RF field).
- improves the Rx filtering, i.e. the “Rx sensitivity”.

“Asymmetrical” vs “symmetrical” small antenna tuning with DPC

Fig. EMVCo “asymmetrical and “symmetrical” tunings with small antenna



Behavior at large distance

1

Symmetric antenna at large operating distance (= low coupling) the improved transfer function

- allows a higher Q-factor in the antenna coil circuit.
- improves the Tx shaping (options).
- improves the power transfer (RF field).
- improves the Rx filtering, i.e. the “Rx sensitivity”.

Behavior at short distance

2

Symmetric antenna at close distance (= strong coupling) **with DPC** delivers enough field strength but not too much due to the DPC regulation

- controls (and limits) the ITVDD.
- controls (and limits) the field strength.
- protects the reader IC.
- ensures to keep the ISO and EMVCo limits.

How to design a “symmetric” antenna for DPC

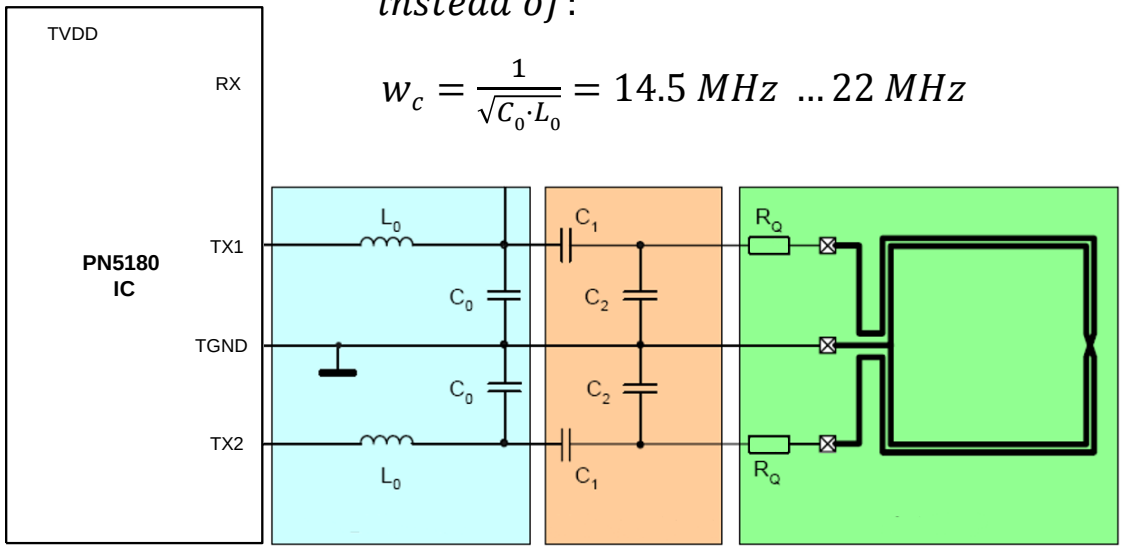
What's the difference from "asymmetric" to "symmetric" antenna tuning?

- EMC cut off frequency ≈ 14.3 ... 14.7 MHz (close to 13.56MHz)
- L0 must be at least > L/2 (L = inductance of antenna coil)
- Q factor of the antenna circuit can be higher:
  - Lower values of damping resistors
  - The Q of EMC filter inductor is important!!! The higher the better!
- The DPC must be properly calibrated!!
  - Otherwise detuning might kill the NFC Reader IC.
  - DPC becomes important!
  - Tx shaping become more relevant.
- Process of tuning is the same!

$$w_c = \frac{1}{\sqrt{C_0 \cdot L_0}} = 14.3\ MHz\ \ldots 14.7\ MHz$$

$$instead\ of:$$

$$w_c = \frac{1}{\sqrt{C_0 \cdot L_0}} = 14.5\ MHz\ \ldots 22\ MHz$$



DPC calibration and correlation test required

Dynamic Power Control

Dynamic Power Control (DPC) at a glance

Robust / Performance with DPC

Controls antenna current, RF power, and the related waveforms to deliver optimized RF performance, even under detuned conditions.

Maximizes the transmitter current during detuned conditions compensating for any negative effects generated by nearby metal, cards, or phones.

Controls the field strength along with the operating range, to stay within the ISO/IEC and EMVCo requirements

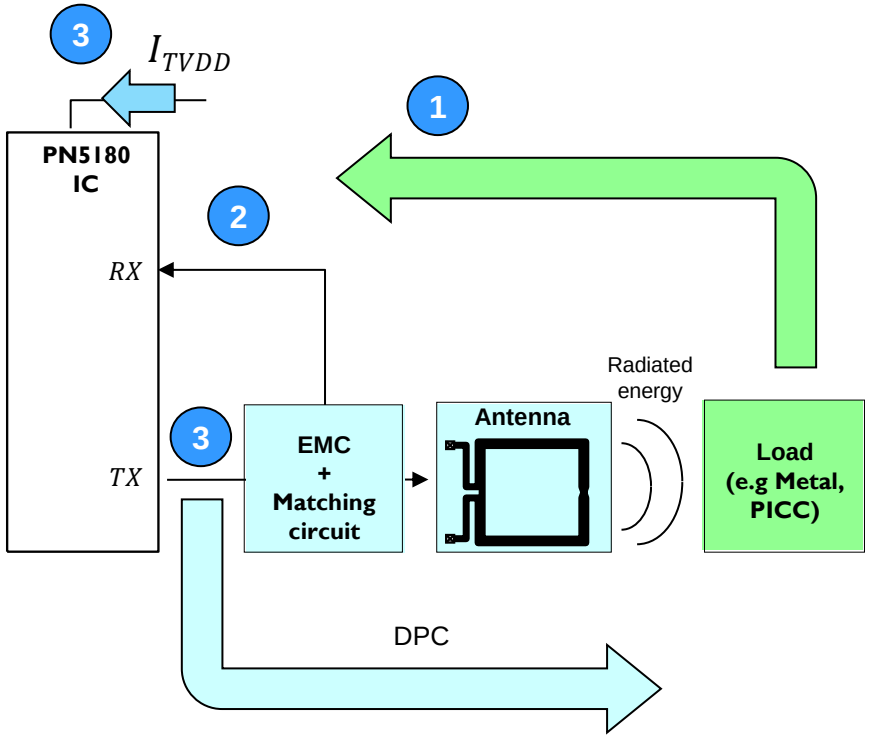
Ensures robust communication with smartcards and smartphones, without using any additional external components.

How does DPC work?

"Symmetrical" antenna with DPC

1. A load change decreases the impedance, i.e. increases ITVDD
2. The DPC uses the changed Automated Gain Control (AGC) value to change TVDD settings
3. The changed TVDD settings reduce the ITVDD and power and field strength

DPC uses gears to control the Tx output power



What needs to be defined for DPC

1

Define number of gears (DPC_AGC_GEAR_LUT_SIZE)

- Up to 15 gears can be stored (i.e. Up to 15 output powe steps can be defined)
- Gear 0 defines the maximum available power
- The highest available Gear (e.g Gear 14) defines the lowest available output power

2

Define Tx settings per gear (DPC_AGC_GEAR_LUT)

- It defines the output power settings per gear.

3

Define high threshold value per gear (DPC_THRSH_HIGH)

- A high threshold value needs to be defined per gear
- It defines the maximum measured field strength per gear.
- The DPC switches to the next gear as soon as this threshold is achieved.

4

Define a shift value to set the low threshold (DPC_AGC_SHIFT_VALUE)

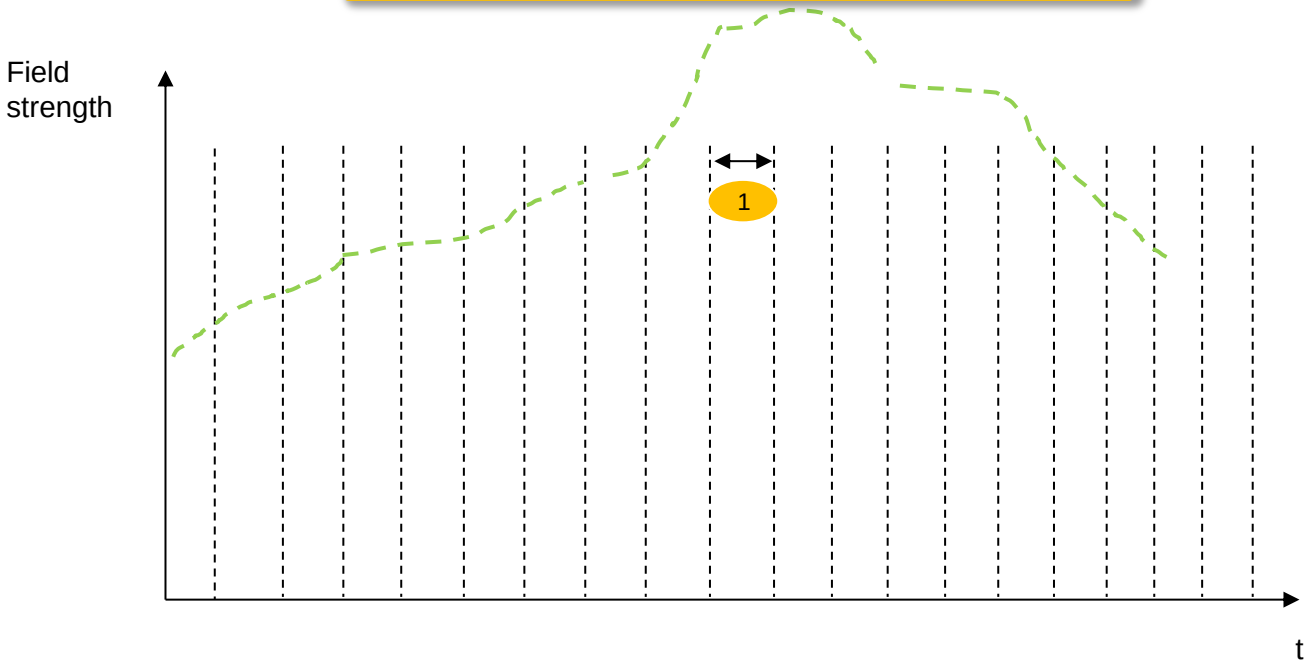
- For switching back from a lower to a higher output power, the field strength needs to become lower than the low threshold.
- This low threshold is dynamically set by the DPC to avoid an oscillation.
- The user must define a shift value which is used to set the low threshold (DPC_AGC_SHIFT_VALUE).

DPC gears principle

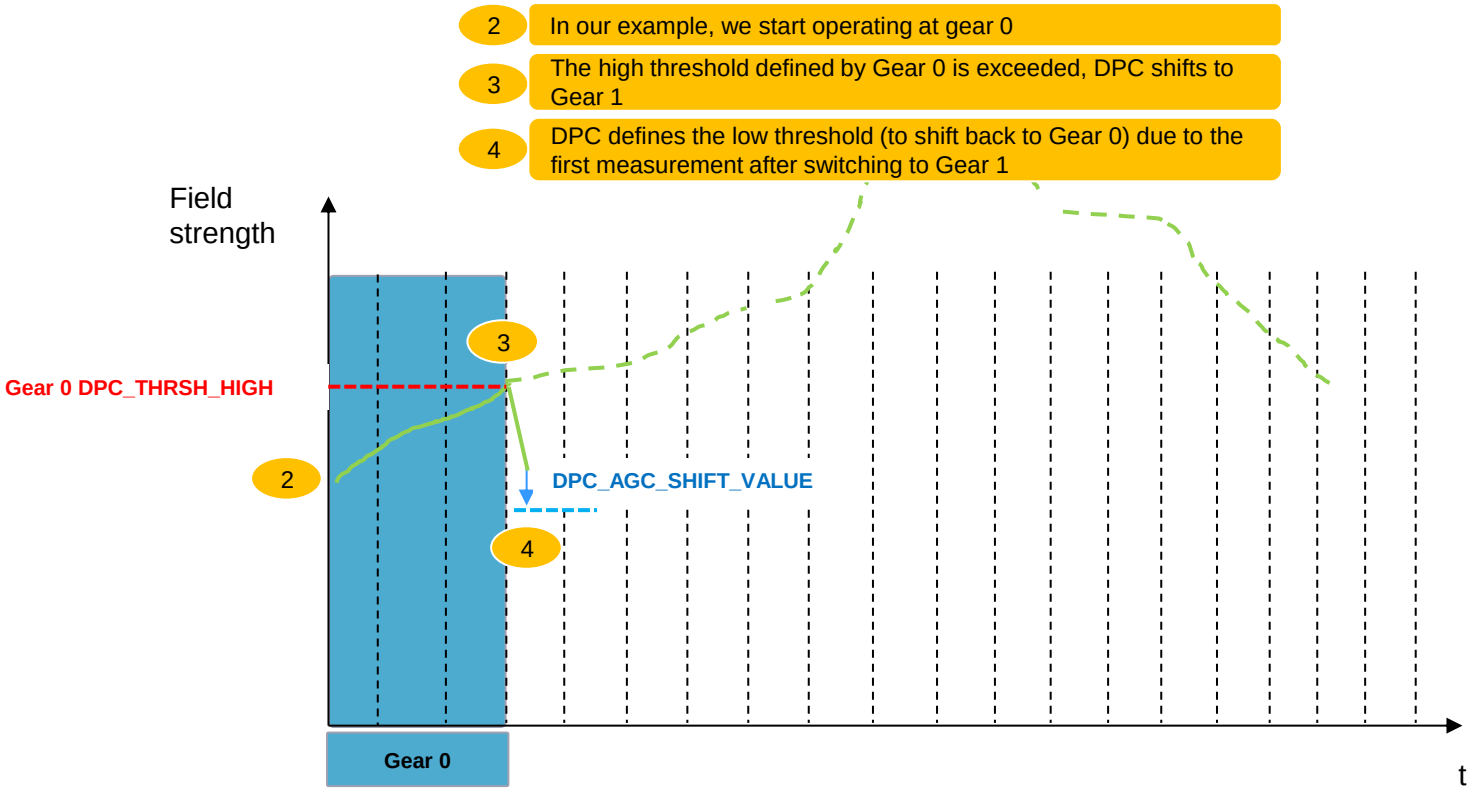
1

The PN5180 DPC dynamically measures the AGC value. The default time interval of this measurement is defined in DPC_TIME register.

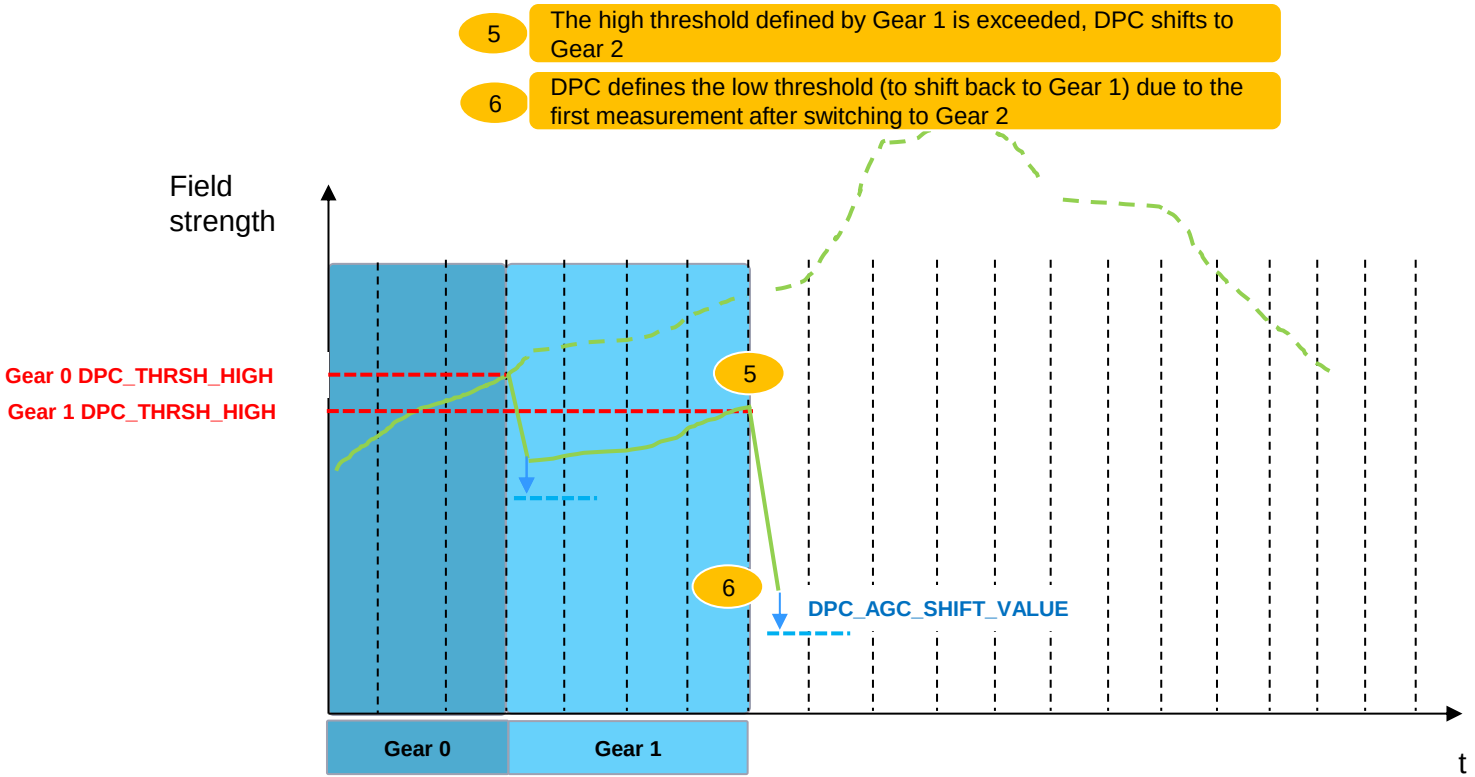
It is recommended to leave this interval as defined by default



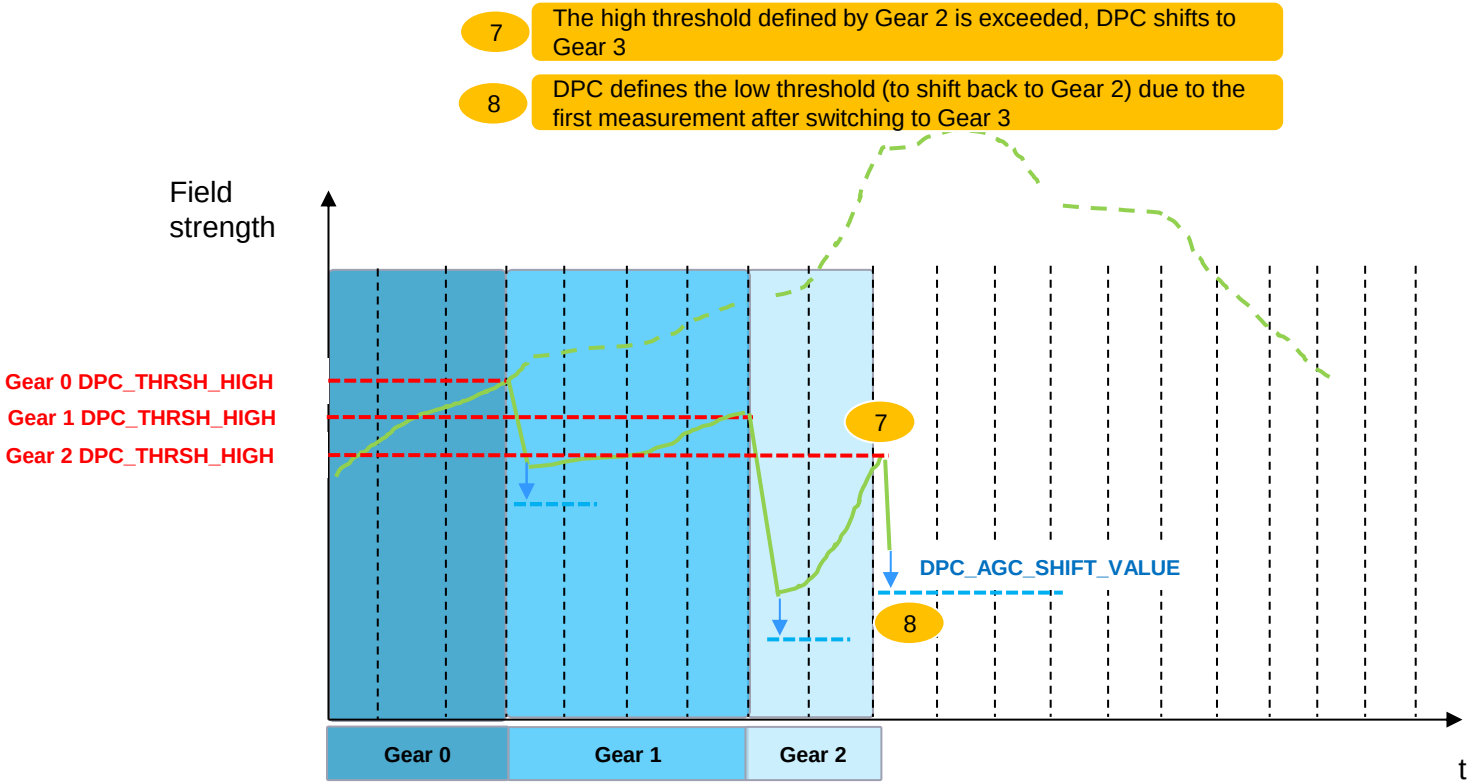
DPC gears principle



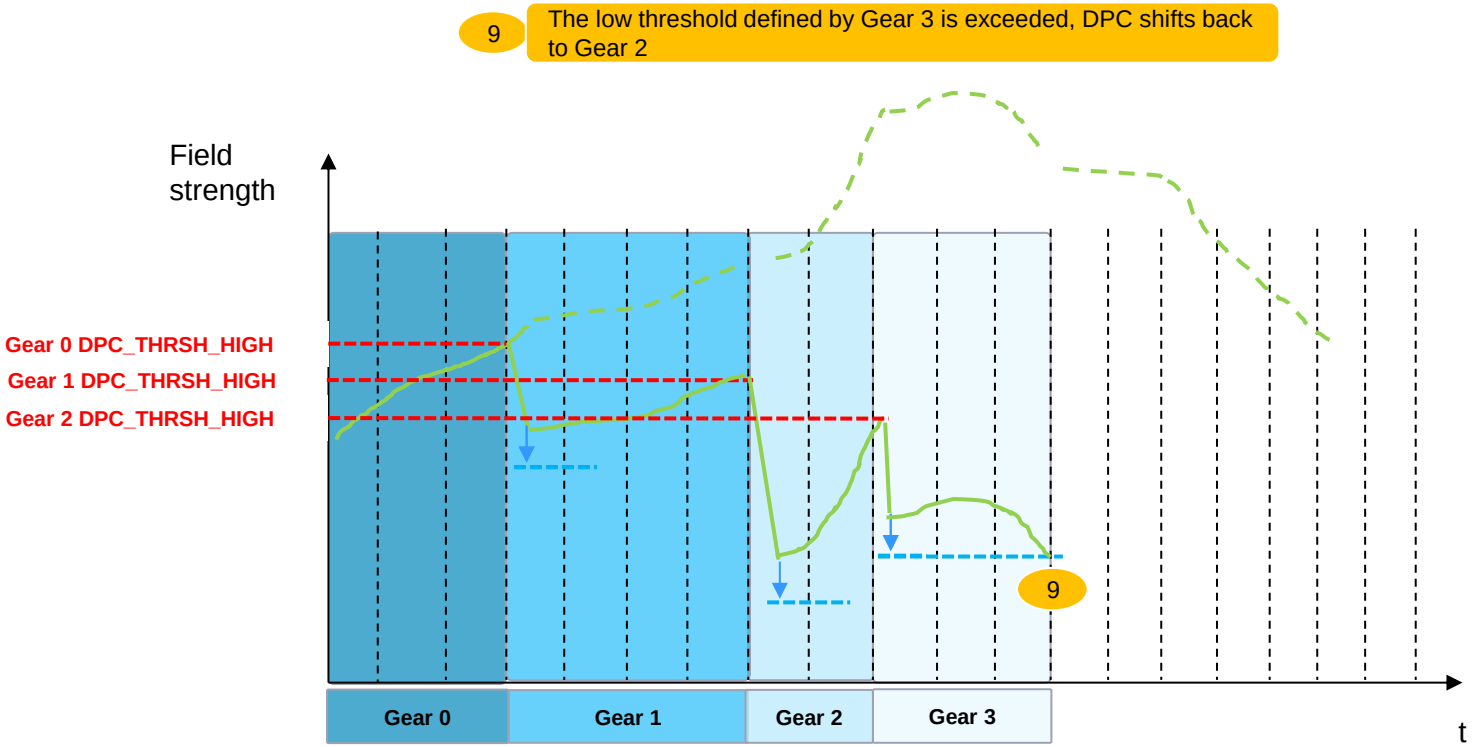
DPC gears principle



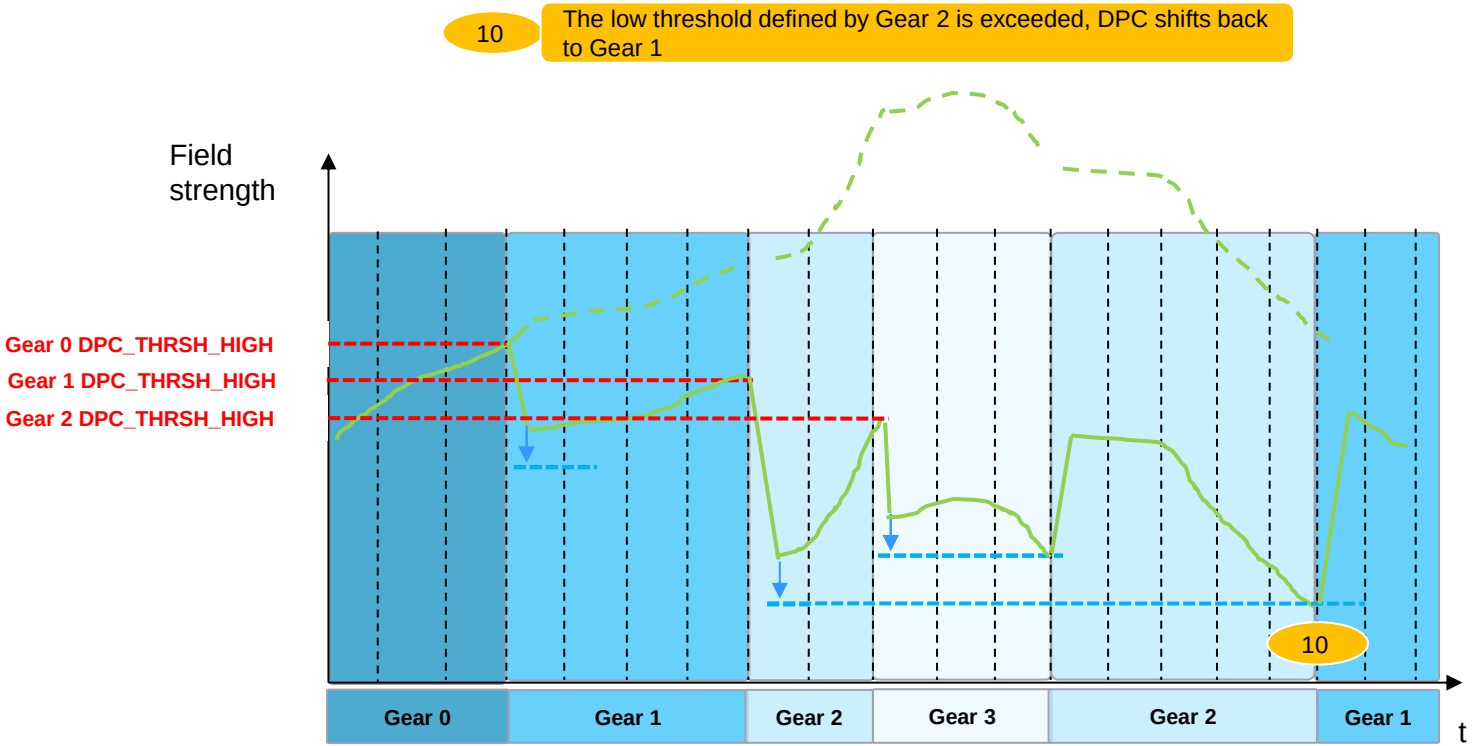
DPC gears principle



DPC gears principle



DPC gears principle



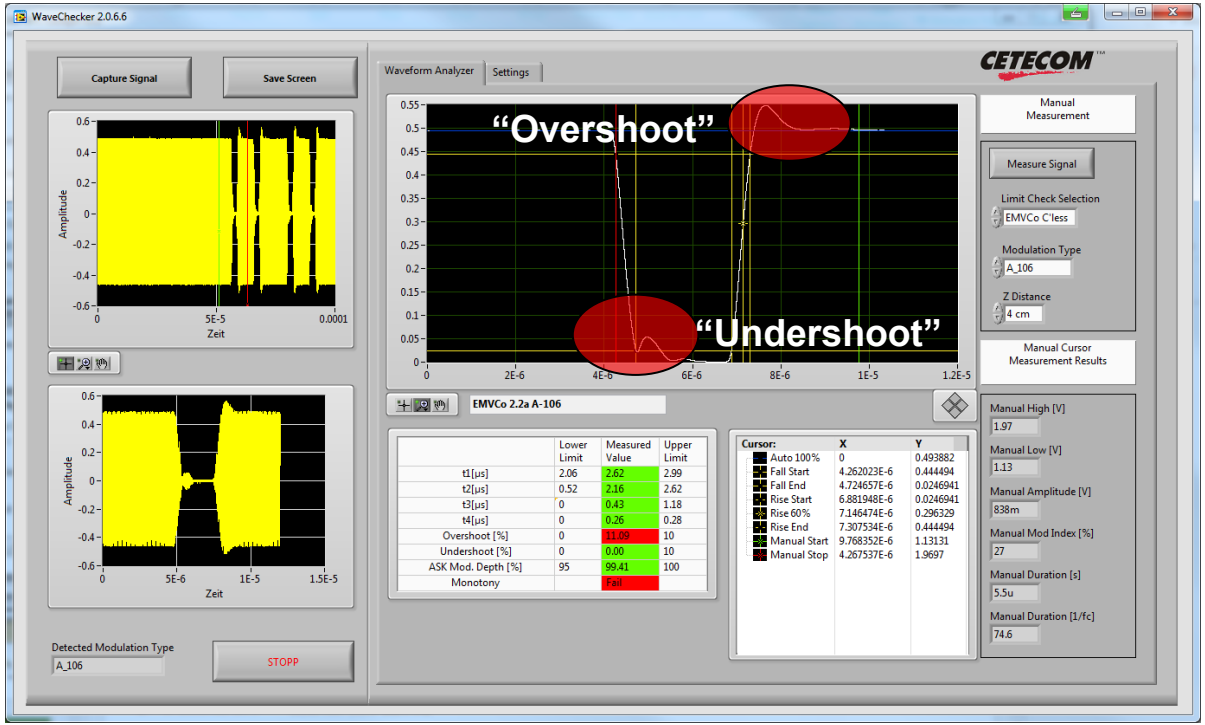
Important considerations about DPC

- Ensure a good correlation between AGC & ITVDD → **Correlation test is required**. Correlation normally is achieved if:
  - DPC antenna tuning is applied (“symmetrical” behavior)
  - L0 (EMC filter) < Lantenna / 2
- DPC calibration is required
  - DPC settings need to be defined **per antenna design**!
- DPC supports a trimming procedure, which allows the compensation of production tolerances
  - The trimming needs to be defined **per device**!
- DPC provides **Tx shaping features**, which help to meet the pulse shape requirements.

NFC Cockpit can be used together with the PNEV5180B for an easy DPC calibration and optimization

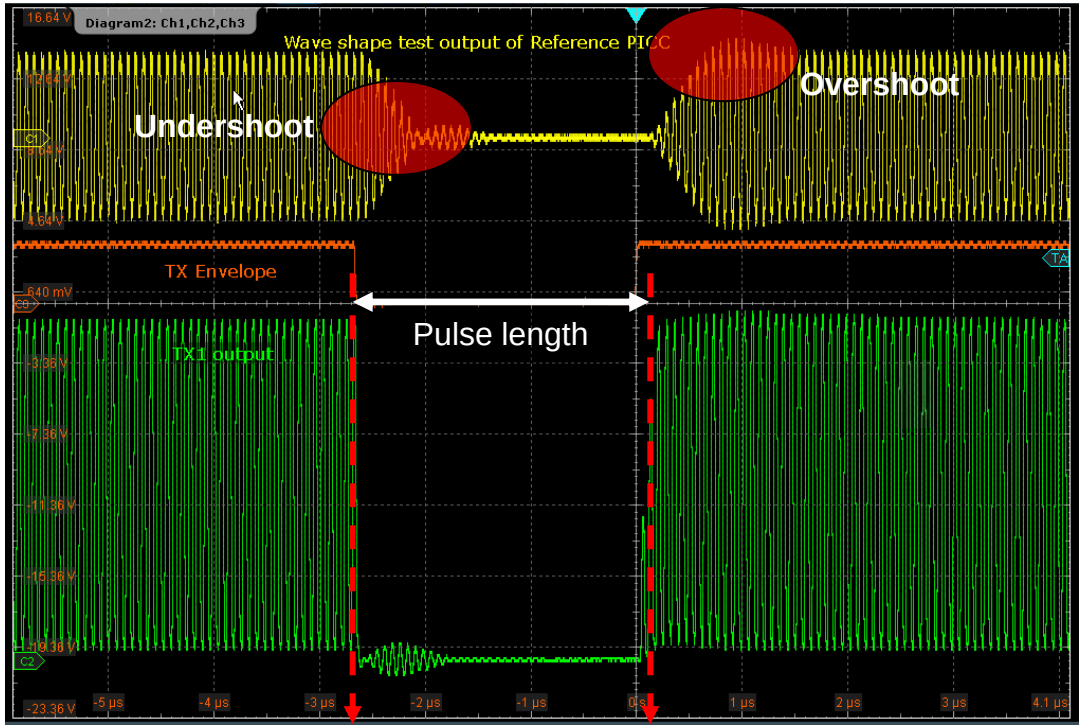
Check & adjust wave shapes with DPC Tx shaping

Why do we need DPC Tx shaping?



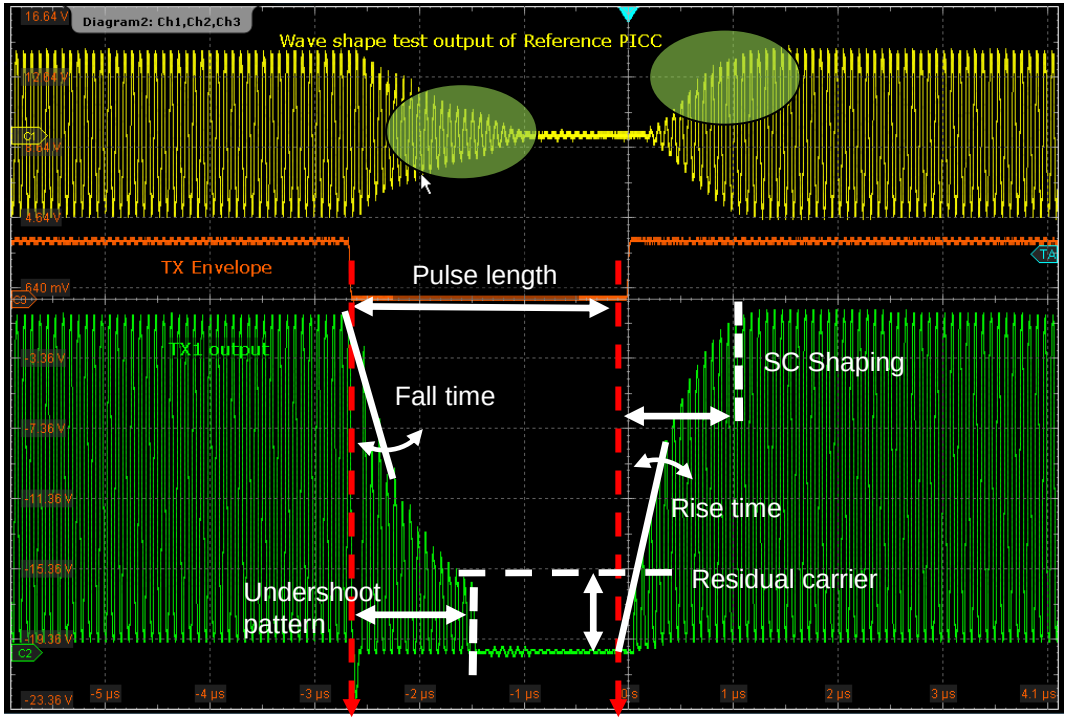
- **OPTION 1: Change antenna tuning**
  - HW change: time consuming
  - Reduce Q-factor: decreases operating distance
- **OPTION 2: Use DPC Tx shaping**
  - EEPROM change: Low effort
  - No change of antenna tuning: same operating distance

Standard Type A pulse shape without DPC Tx shaping



- The short fall and rise times in a typical DPC antenna design may generate overshoots on both the falling and the rising edgy of the envelope.
- This can be corrected with the Tx shaping features

Standard Type A pulse shape with DPC Tx shaping



Most relevant registers and settings:

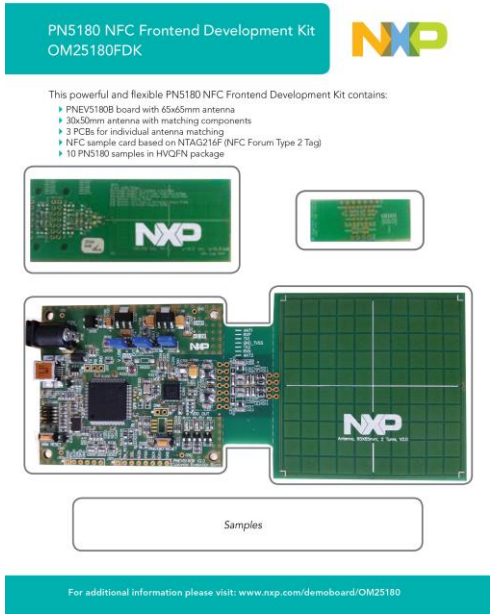
- TX_UNDERSHOOT_CONFIG
  - TX_UNDERSHOOT_PATTERN_LEN
  - TX_UNDERSHOOT_PROT_ENABLE
- RF_CONFIG_TX
  - TX_RESIDUAL_CARRIER
  - TX_SET_BYPASS_SC_SHAPING
  - TX_SET_TAU_MOD_FALLING
  - TX_SET_TAU_MOD_RISING
- RF_CONTROL_TX_CLK
  - TX_CLK_MODE_OVUN_PREV
  - TX_CLK_MODE_RM

Product support package

Development kit, SW tools, SW examples and documentation

PN5180 NFC frontend development kit OM25180FDK

- PNEV5180B Evaluation board embeds the PN5180 high integrated and high power output NFC frontend IC. PN5180 combines the features of the PN512 and the CLRC663.
- PNEV5180B can be used for SW development, hardware design, to explore PN5180 functionality and perform RF and antenna design related tests.
- PNEV5180B board with 65x65mm antenna and 30x50mm antenna with matching components.
- LPC1769 uC mounted fix on the board. SPI interface accessible for connection of other uC.
- CE/FCC certified PNEV5180B board.

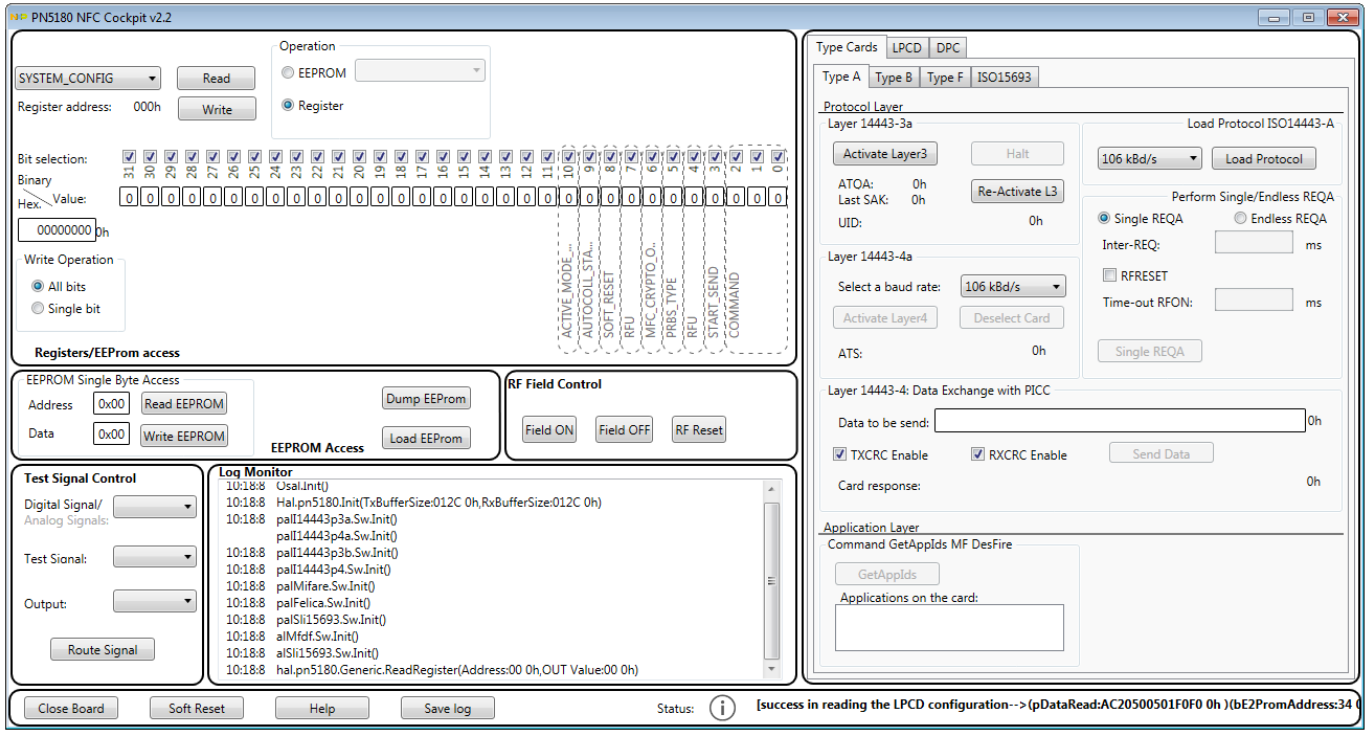


Demokits at edemoboard portal

Reference	12NC	Product description
OM25180FDK	935307319699	PN5180 NFC frontend development kit

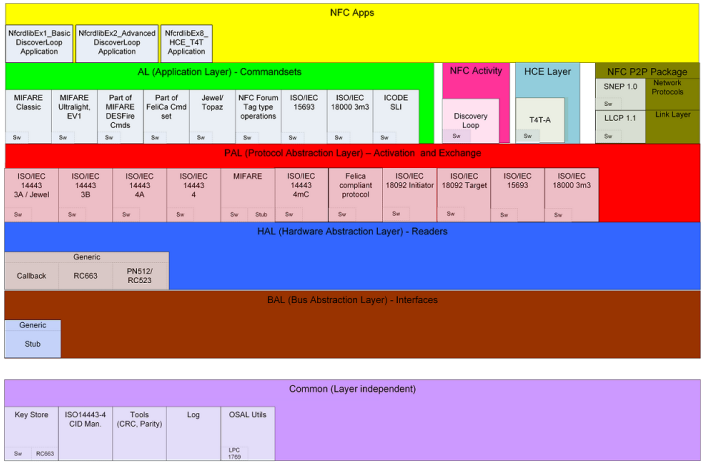
NFC Cockpit, the complete design tool for engineers

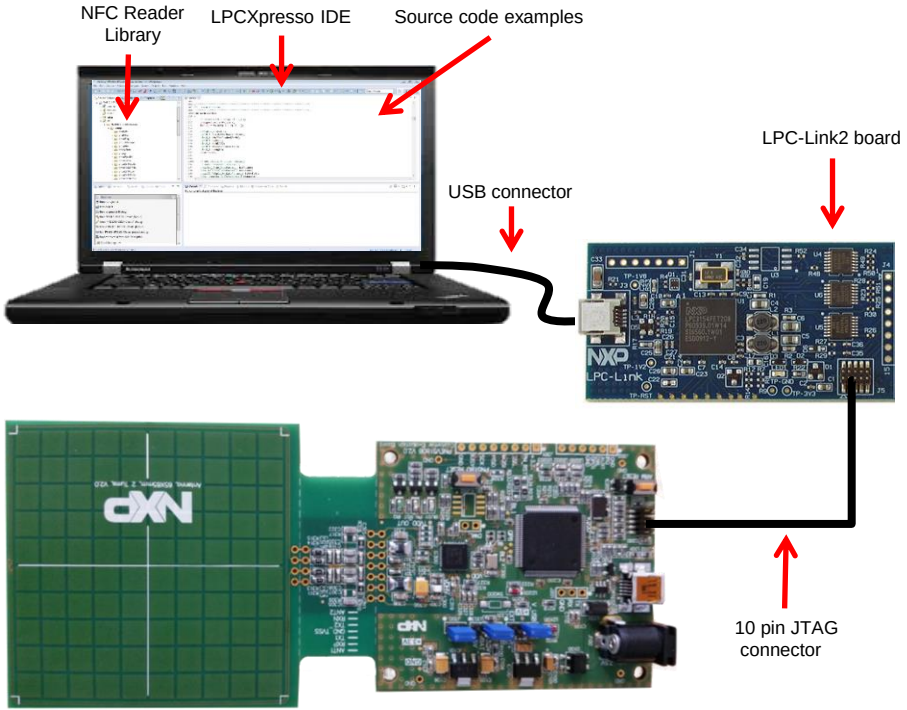
- The NFC Cockpit is a PC based interface which allows to easy control all PN5180 functions.
- The support tool is composed of 6 main parts:
  - Registers and EEPROM access
  - Low Power Card Detect(LPCD)
  - Dynamic Power Control(DPC)
  - Test signals control
  - Generic commands
  - Log monitor
  - Type cards
  - Status bar



Easy test and debugging based on NFC Reader Library examples

- The NFC Reader Library is encapsulated into layers and components written in ANSI C.
  - Each layer consists of different components having a generic interface and a specific implementation
- The library structure provides a modular way of programming and setting up the reader interface.





PN5180 product documentation and SW files

Doc ID	Doc Name	Description
75017673	PN5180 leaflet	High performance full NFC Forum compliant frontend
PN5180	PN5180 product datasheet	This document describes the functionality and electrical specification of the PN5180 NFC frontend
AN11742	PN5180 Dynamic Power Control	This document describes how to use the Dynamic Power Control feature
AN11744	PN5180 evaluation board quick start guide	This document describes the PN5180 evaluation board and how to use it. It describes the NFC Cockpit v2.2 which allows an easy basic access to the PN5180 registers and EEPROM in combination with basic reader functionality
AN11740	PN5180 antenna design guide	This document describes the “standard” antenna design and tuning related to the PN5180
AN11741	How to design an antenna with DPC	This document describes the “symmetrical” antenna design, which must be used together with the Dynamic Power Control (therefore, called DPC antenna tuning).
UM10954	PN5180 SW quick start guide	This User Manual is related to the installation procedures of the PN5180 evaluation board, SW sample projects as well as the re-installation of the original LPC firmware to run the NFC Cockpit. It describes the steps to be done to become acquainted with the demo reader especially for the SW development
SW3524	Installer package PN5180 NFC Cockpit v2.2	This file contains the NFC Cockpit GUI v2.2 installer
SW3522	NFC Reader Library for PNEV5180B including all SW examples	This file contains the NFC Reader Library for PNEV5180B including SW source code examples
SW3545	PN5180 antenna design tools	This file contains an Excel sheet for the calculation of the matching and tuning components for an NFC Reader antenna, including a macro for RFSIM99

Final remarks

PN5180 in a nutshell

Target markets	Ideal product for payment terminals, access readers or industrial readers needing to generate a strong RF field in a difficult environment
Position in portfolio	› Very high power NFC frontend which will enhance our strong frontend portfolio based on PN512 and CLRC663 family › New features such as Dynamic Power Control which simplifies antenna tuning and grants an optimized communication with cards or mobile phones
Interoperability	› Fully compliant with EMVCo and NFC Forum › Full interoperability with a broad range of smart card and mobile phones on the market
Software	PN5180 NFC Library: ideal software companion, easily portable on various microcontrollers cores, fully compliant with EMVCo L1 and NFC Forum digital certifications
Support tools	CE/FCC demo-board incl. LPC controller and a removable antenna in a kit, NFC Cockpit (GUI) allows configuration and RF tests without the need of programming dedicated software, documentation and pre-certified EMVCo & NFC Forum software stack

Ordering information and samples

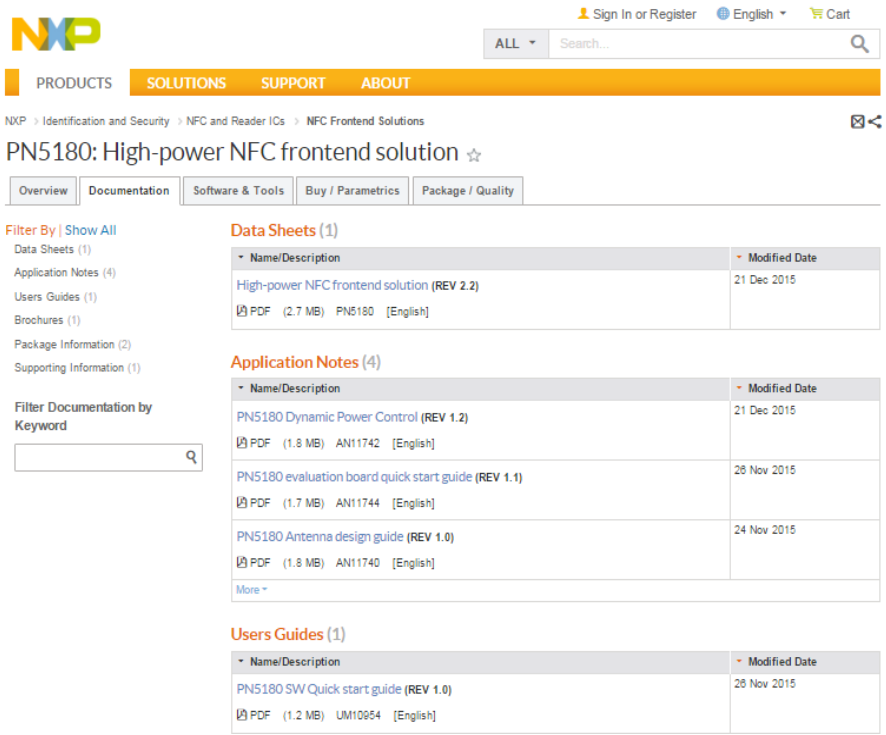
Type Number	12NC	Package	Packaging	MOQ
PN5180A0HN/C1	935307006518	HVQFN40	Reel	4000
PN5180A0HC/C1	935307006551	HVQFN40	Tray	490
PN5180A0ET/C1	935307007118	TFBGA64	Reel	4000
PN5180A0ET/C1	935307007151	TFBGA64	Tray	490

Product samples can be ordered from eSample by clicking on “NXP Customer Support” → “Samples”

Do you need more?

Resources and useful links

- NFC Everywhere
  http://www.nxp.com/products/identification-and-security/nfc-and-reader-ics/nfc-everywhere:NFC-TECHNOLOGY
- NFC Everywhere support page
  http://www.nxp.com/techzones/nfc-zone/community.html
- PN5180 product website
  http://www.nxp.com/products/identification-and-security/nfc-and-reader-ics/nfc-frontend-solutions/high-power-nfc-frontend-solution:PN5180
- OM25180FDK demokit website
  www.nxp.com/board/OM25180FDK.html
- NFC innovation lab video to get a quick intro into the new features that come along with the PN5180
  https://www.youtube.com/watch?v=Q0jFC27TLEQ
- NXP Tech community
  http://nxpcommunity.force.com/community/CommunityOverview



PN5180 – The best full NFC frontend on the market

Jordi Jofre (Speaker) / Eric Leroux (Host)

Time for

Q & A

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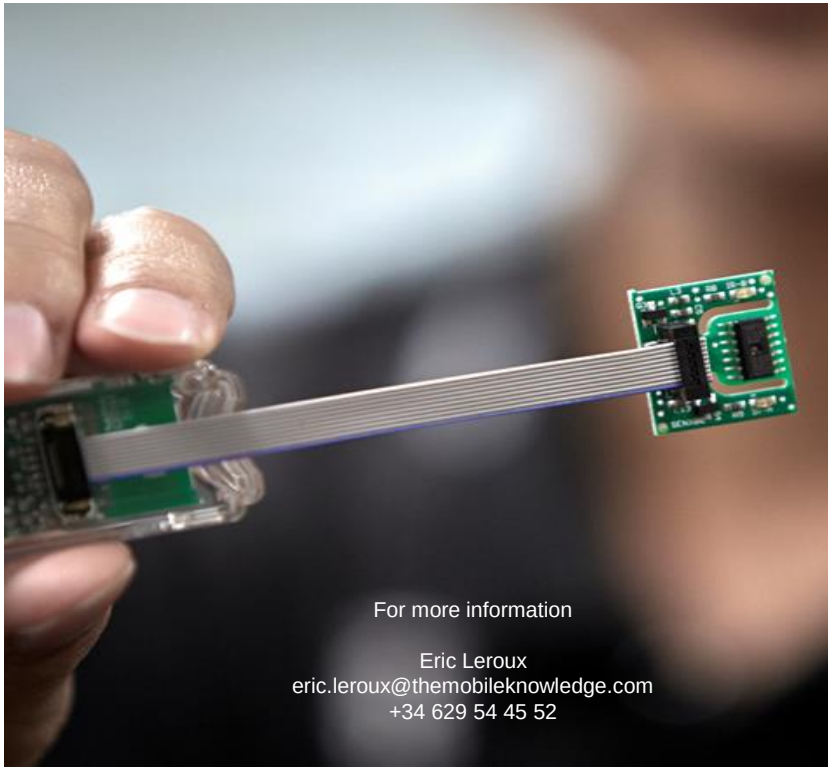
- We address all the exploding identification technologies that include NFC, secure micro-controllers for smart cards and mobile applications, reader ICs, smart tags and labels, MIFARE family and authentication devices.



NXP Training Mobile Knowledge

PN5180 – The best full NFC frontend on the market

Jordi Jofre (Speaker) / Eric Leroux (Host)

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

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