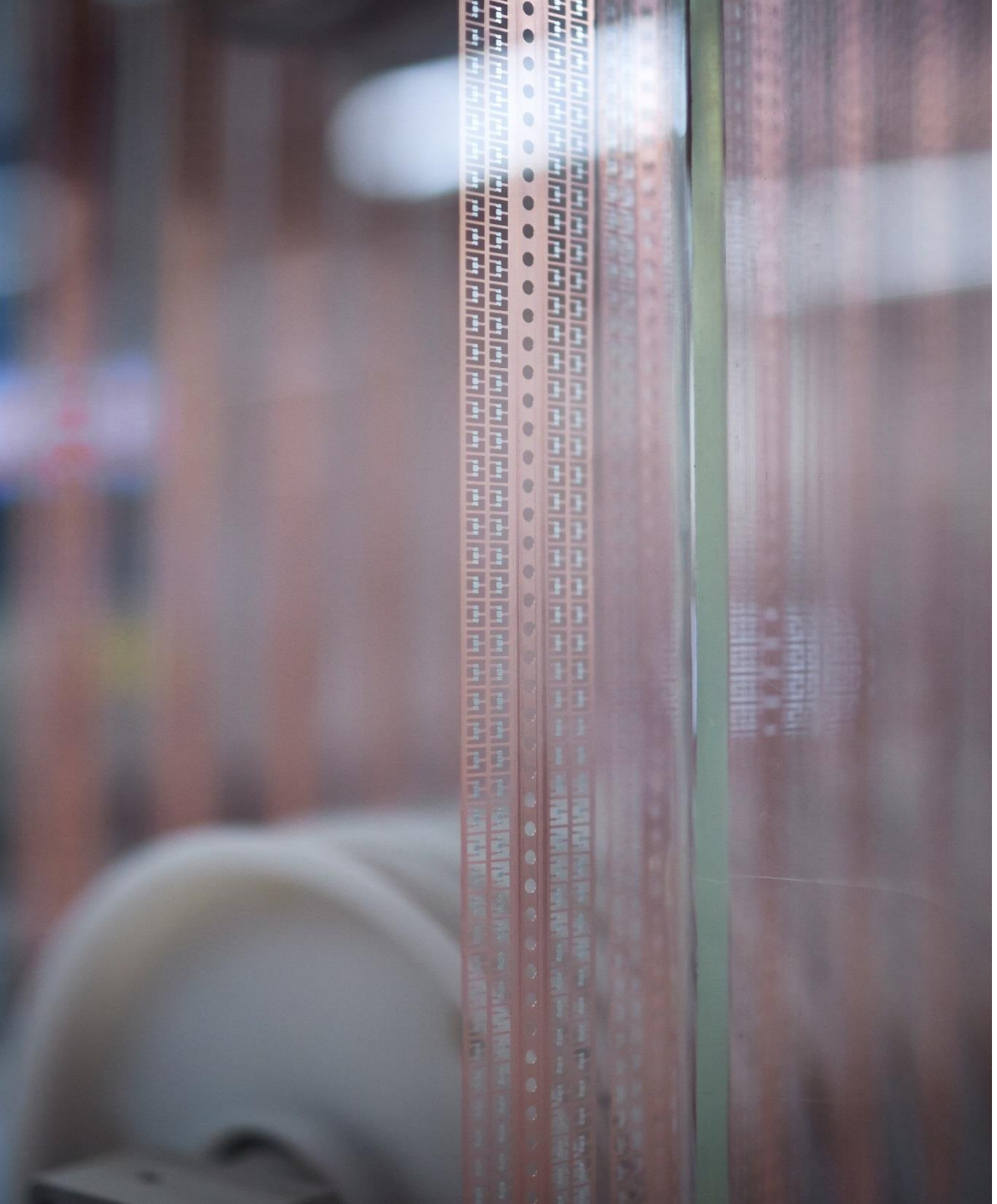
# GET AHEAD WITH NXP'S PN5180 FRONTEND - DESIGN YOUR POS TERMINAL WITH EMVCO (L1) CERTIFICATION

## SESSION 2: PN5180 FOR EMVCO L1 CONTACTLESS CERTIFICATION

PABLO FUENTES

JULY 2018



# Get ahead with NXP’s PN5180 Frontend - Design your POS terminal with EMVCo (L1) certification

Session I, 28th June

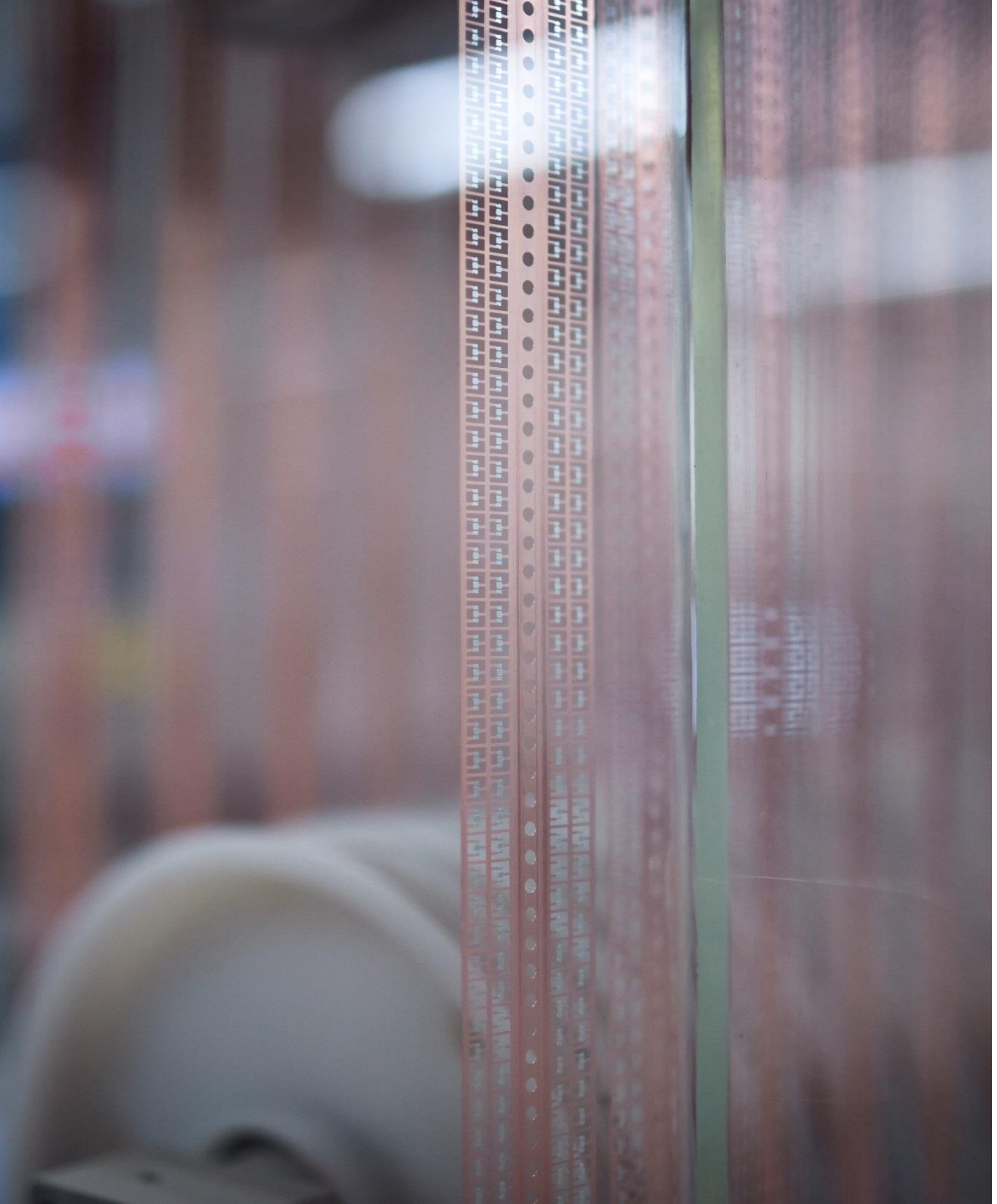
**EMVCo L1 Contactless certification process**

https://attendee.gotowebinar.com/rt/3034896575464625666

Session II, 17th July

**PN5180 for EMVCo L1 Contactless certification**

https://register.gotowebinar.com/rt/5226533311901393666





# Agenda

- Recap from session I
- PN5180 Antenna design considerations
- Power tests
- Waveform tests
- Reception tests
- PN5180 Ecosystem
- More support

# Recap from session I

# Recap from session I

## EMV Analog L1 Test cases

- Power tests
- Waveform tests
- Reception tests

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Training Mobile Knowledge

# Recap from session I

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- Waveform tests
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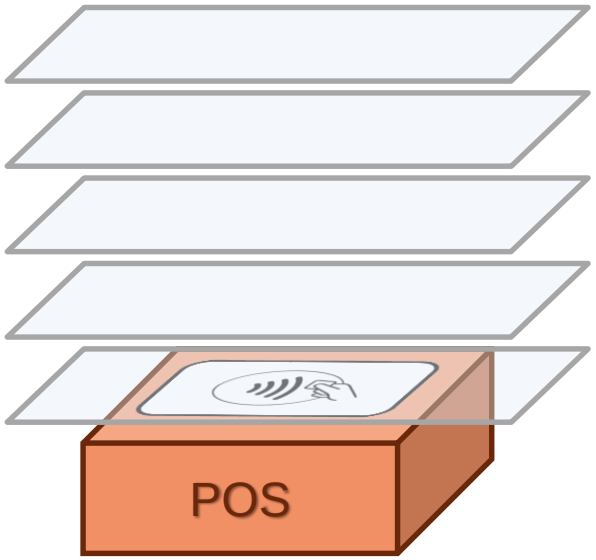


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Training Mobile Knowledge

# Recap from session I

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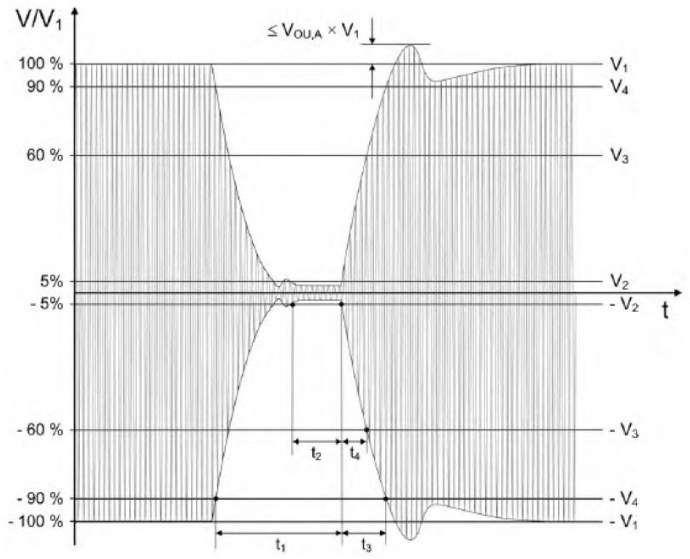
- Power tests
- **Waveform tests**
- Reception tests

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Training Mobile Knowledge

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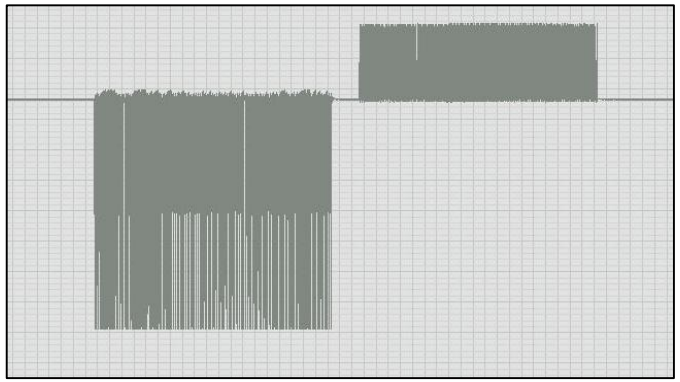

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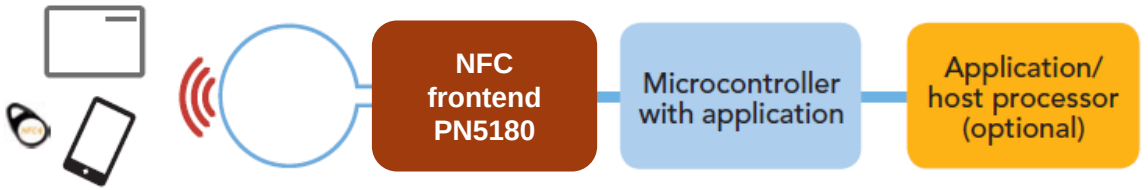
# Recap from session I

## PN5180 key features


- Multi-protocol and high RF performance
- Full NFC Forum and EMVCo compliant frontend
- Flexible low power card detection
- Efficient, robust and reliable operation even in harsh conditions
- Maximum interoperability for next generation of NFC phones
- Onboard Dynamic Power Control (DPC) for optimized RF performance
- Fast SPI host interface with optimized commands for use with 32-bit host controllers
- Small, industry-standard packages with BGA form factor for PCI compliancy






Training Mobile Knowledge

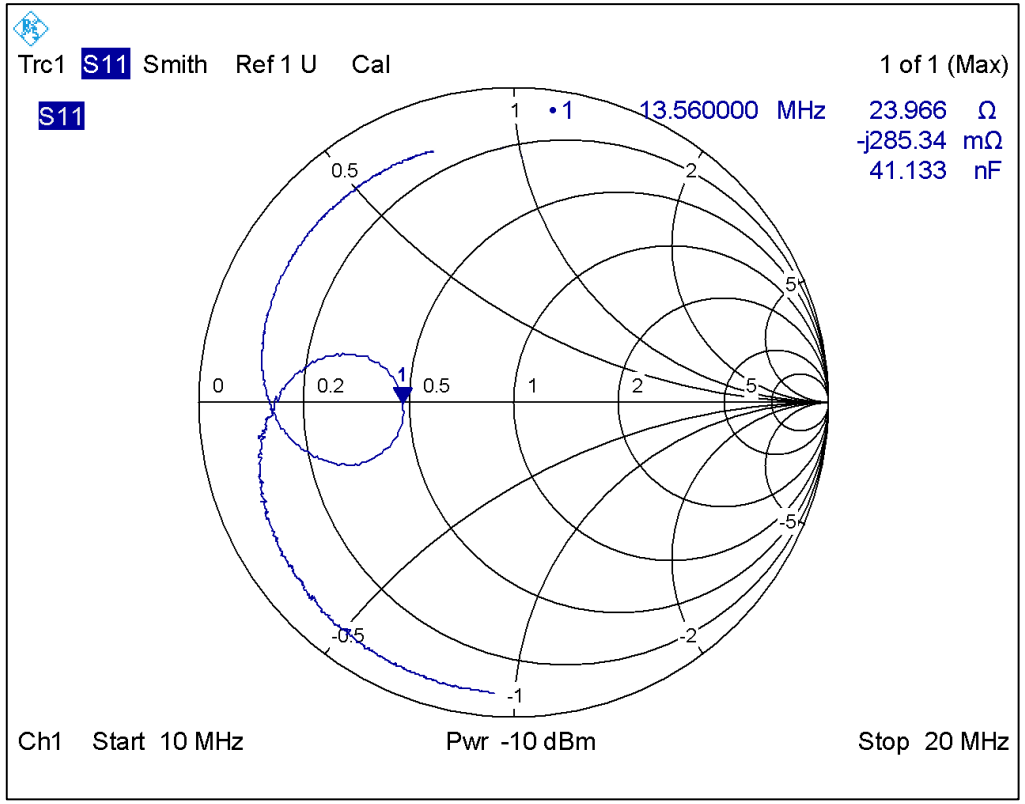
# PN5180 Antenna design considerations for EMVCo

# Antenna design considerations for EMVCo

## Antenna tuning

Recommendations for an optimum antenna tuning of the PN5180:

- Use a symmetrical tuning
  - Provides more power transfer
  - Better transfer function
  - Requires current limiter/controller
- Adjust EMC filter and matching network
  - $L_0 \geq \frac{L_{AntennaCoil}}{2}$ to ensure proper AGC-ITVDD correlation
  - Recommended EMC cut off freq: $f_{EMC} \approx 14.3...14.7MHz$
- Set Rx resistor:
  - Reader Mode only design: AGC value in free air around $600_{dec}$
  - Full NFC design: AGC value in free air around $300_{dec}$
- EMVCo bitrate (106kbps) allows for a higher Q factor
  - Positive for the power gain
  - Might cause issues in waveform tests




*Symmetrical tuning example*



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# Antenna design considerations for EMVCo

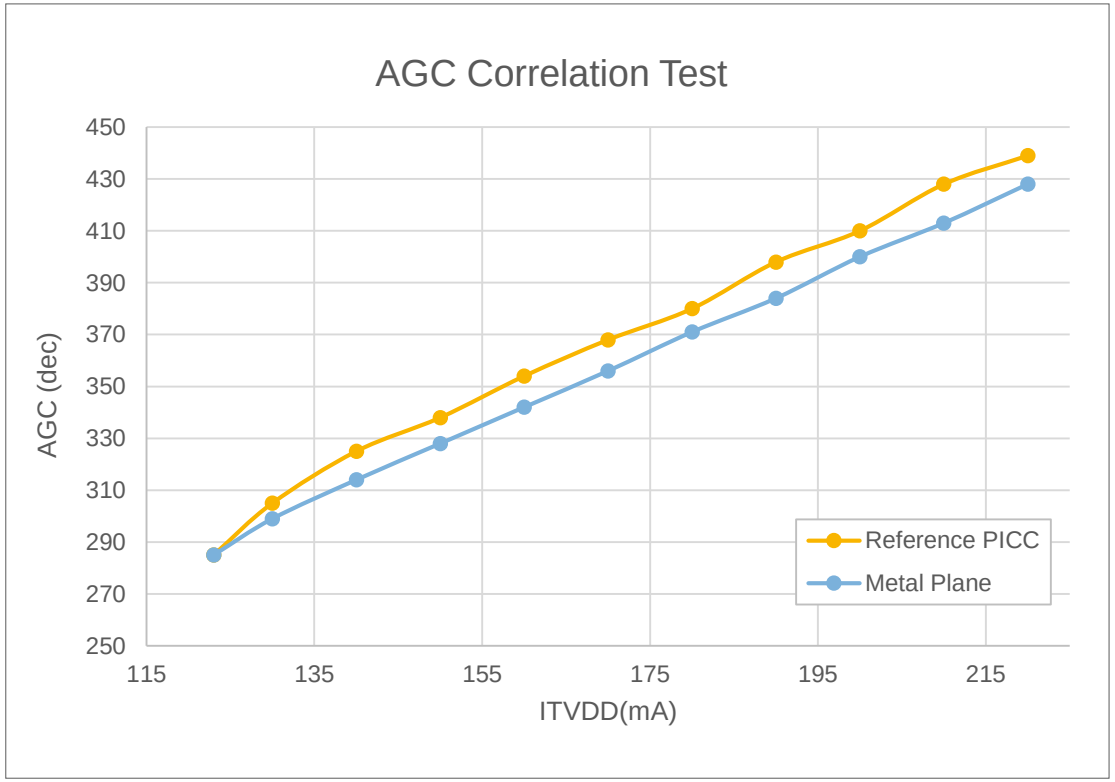
## AGC Correlation and DPC calibration

**1. Check AGC and ITVDD correlation**

- Use different loads (e.g., reference PICC, metal plane...)
- It prevents unexpected behavior with other loads

**2. Calibrate DPC:**

- Keep transmitter current below 250 mA (recom. ~230mA)
- Use maximum power settings for plane z = 4
- Set different gears depending on the z plane



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# Antenna design considerations for EMVCo

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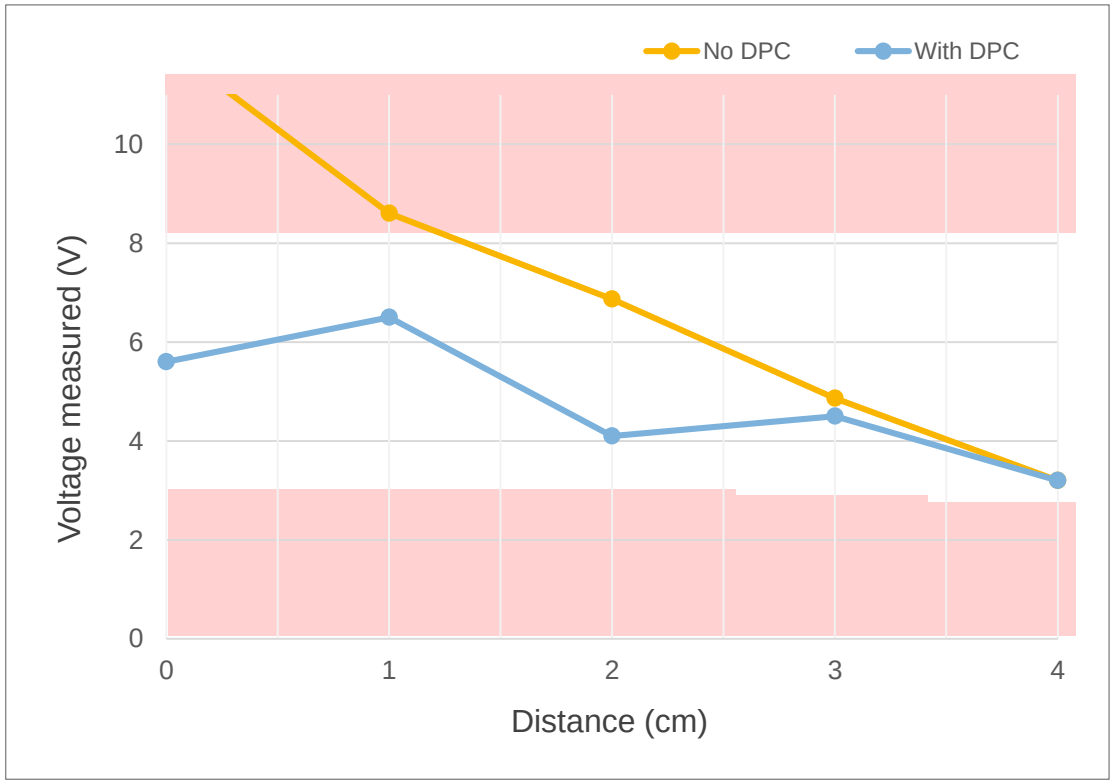


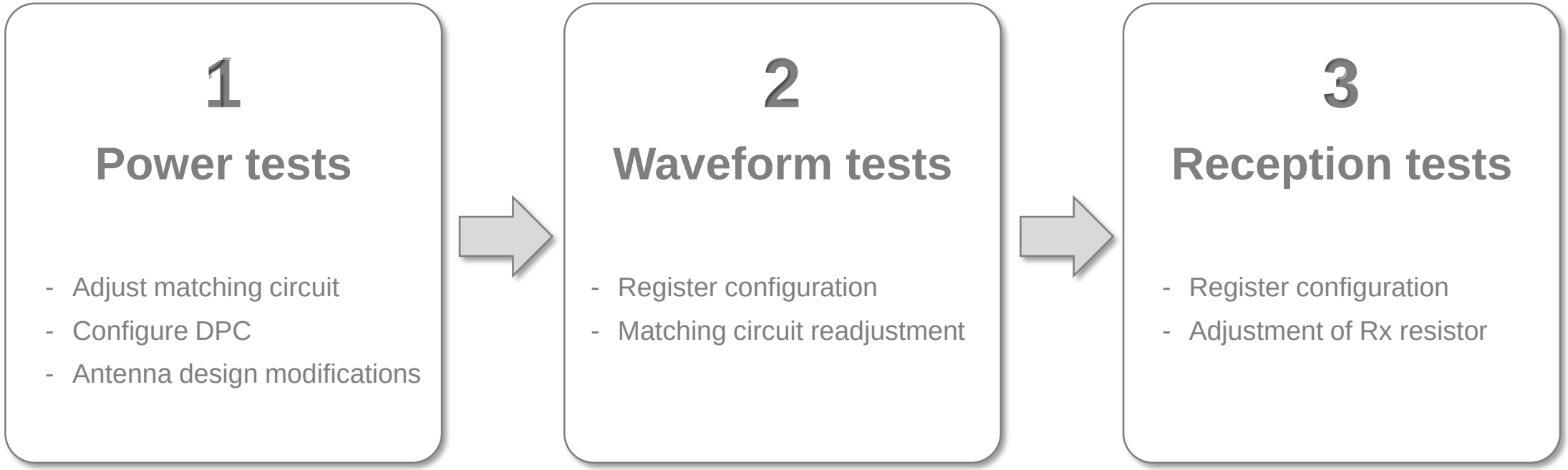



Training Mobile Knowledge

# EMV L1 Analog tests
## *Debugging process*

# EMV L1 Analog tests

## Debugging process



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# EMV L1 Analog
# Power tests

# EMV L1 Analog - Power tests

## Content

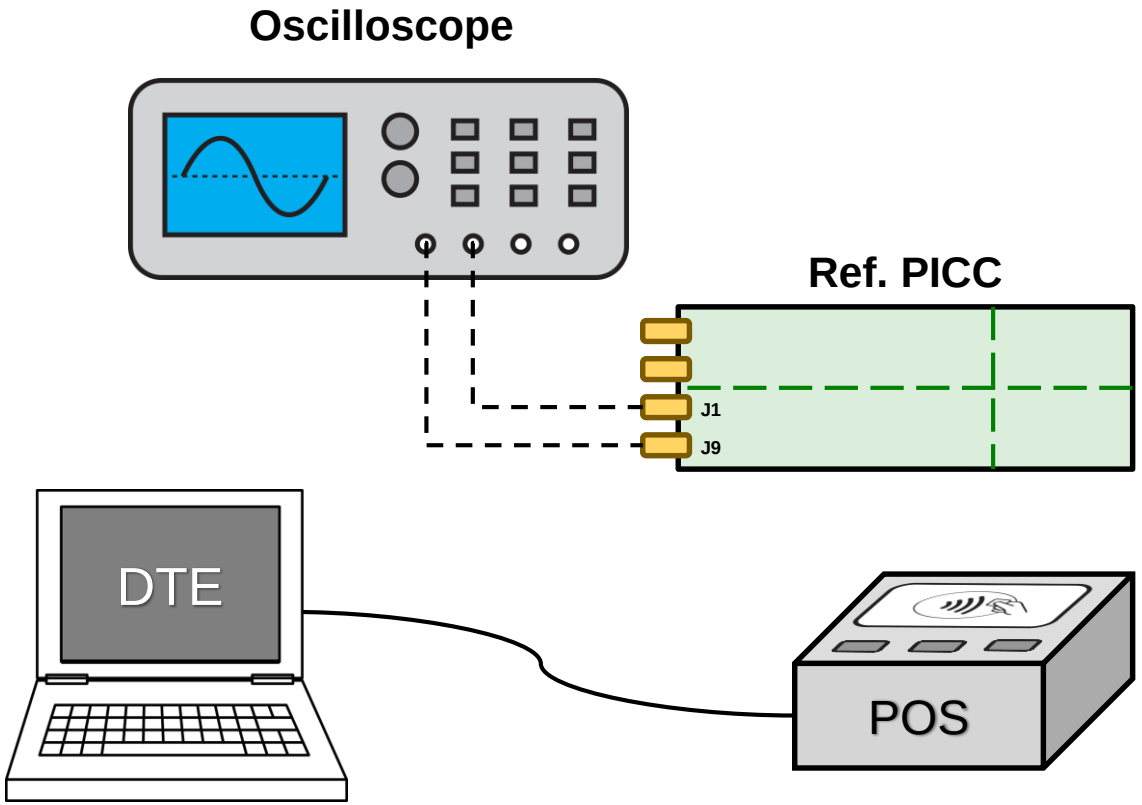
- Test setup
- Performing tests
- Critical positions
- Debugging hints

# EMV L1 Analog - Power tests

## Test setup



1. Connect J9 of ref PICC to oscilloscope Ch1
2. Connect J1 of ref PICC to oscilloscope Ch2
3. Set ref PICC J8 in non-linear load mode (1-4)
4. Configure oscilloscope trigger:
   - Ch1, Rising edge
5. Set the DTE in loopback mode

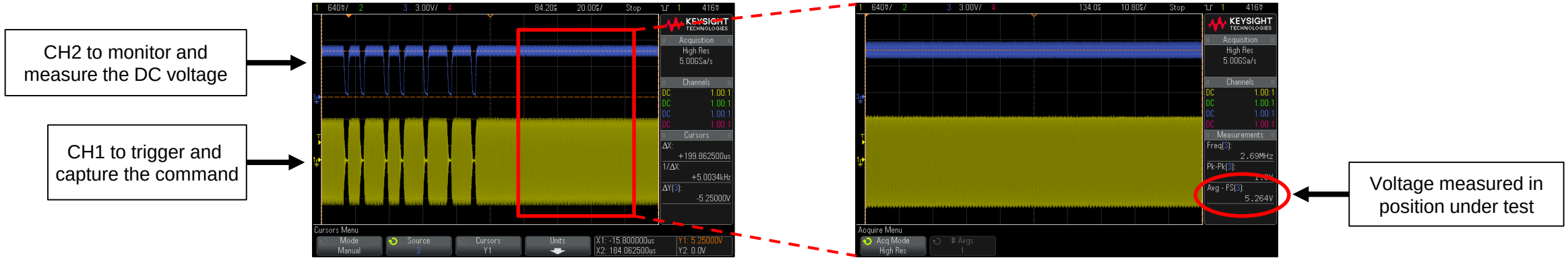


# EMV L1 Analog - Power tests

## Performing tests



1. Place the reference PICC in the target position
2. Send a REQA command
3. Measure voltage level at DC_OUT jumper in a non-modulated period



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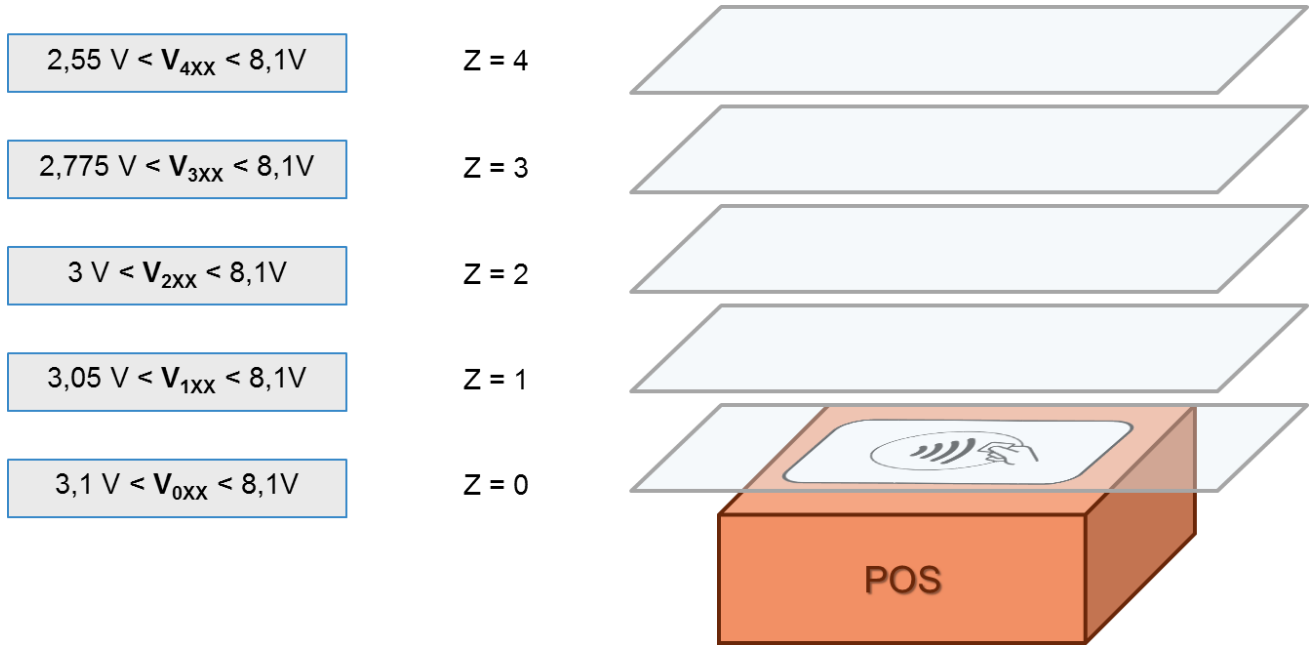




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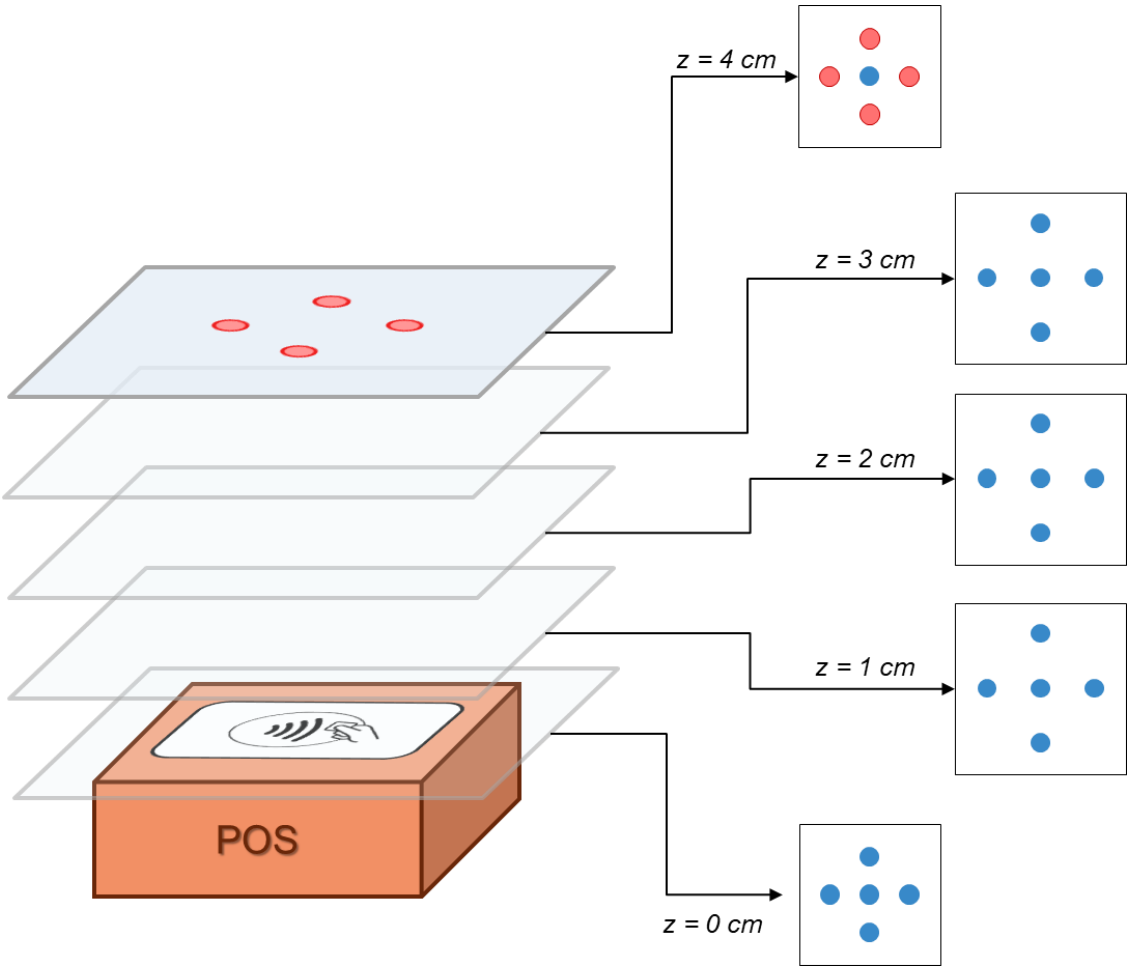
# EMV L1 Analog - Power tests

## Critical positions



1. **External positions in plane Z = 4 cm**
   - Position (4, 1, 0)
   - Position (4, 1, 3)
   - Position (4, 1, 6)
   - Position (4, 1, 9)
2. **External positions in plane Z = 3 cm**
   - Position (3, 2, 0)
   - Position (3, 2, 3)
   - Position (3, 2, 6)
   - Position (3, 2, 9)
3. **Central position in plane Z = 1 cm**
   - Position (1, 0, 0)

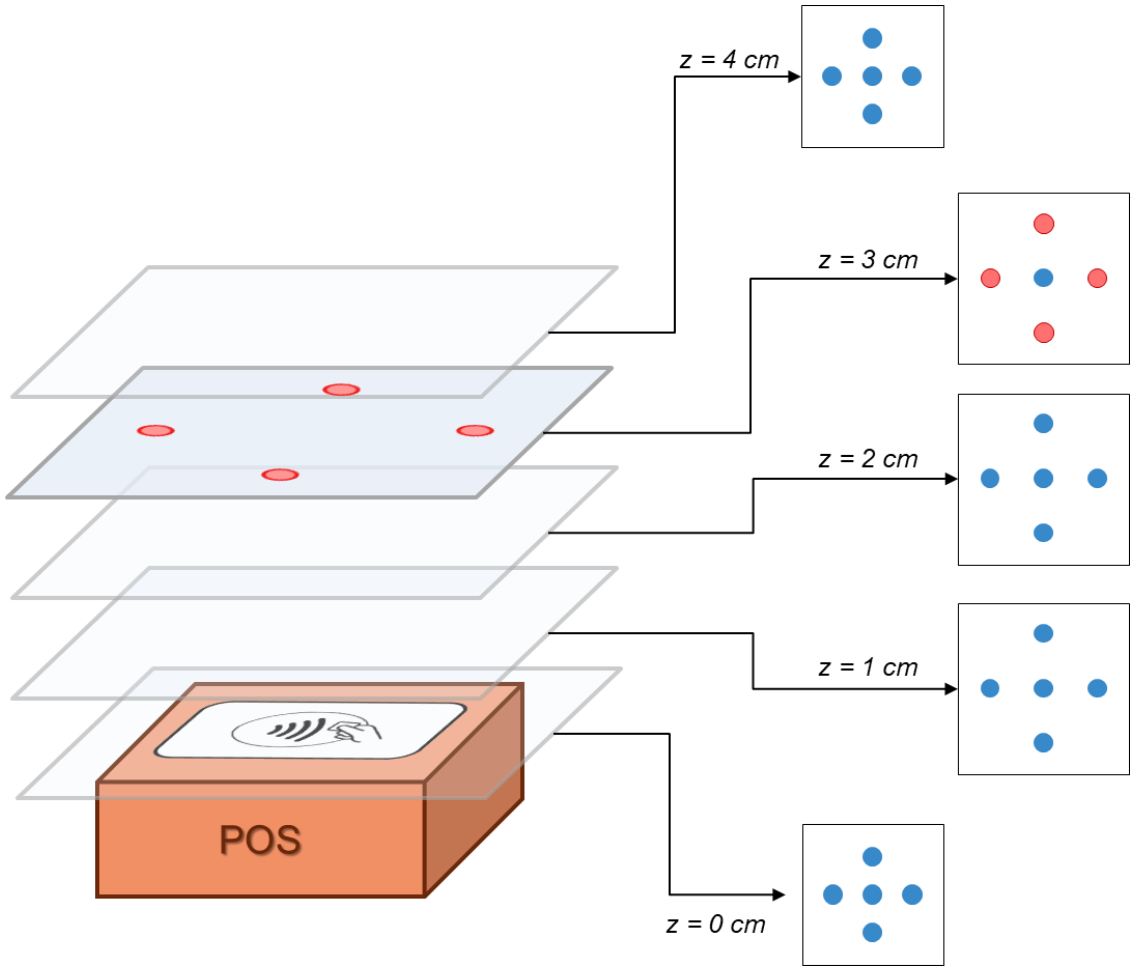


# EMV L1 Analog - Power tests

## Critical positions



1. External positions in plane Z = 4 cm
   - Position (4, 1, 0)
   - Position (4, 1, 3)
   - Position (4, 1, 6)
   - Position (4, 1, 9)
2. **External positions in plane Z = 3 cm**
   - Position (3, 2, 0)
   - Position (3, 2, 3)
   - Position (3, 2, 6)
   - Position (3, 2, 9)
3. Central position in plane Z = 1 cm
   - Position (1, 0, 0)

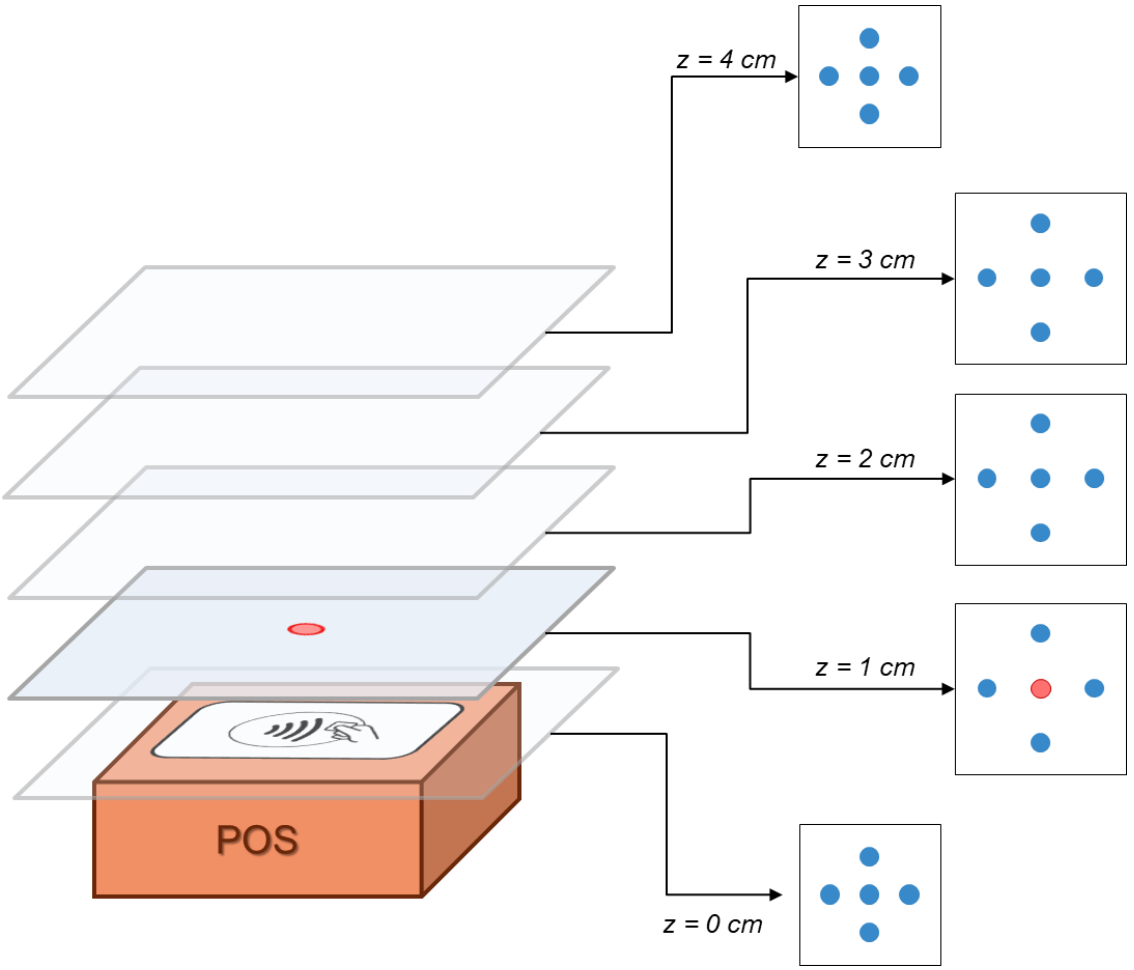


# EMV L1 Analog - Power tests

## Critical positions



1. **External positions in plane Z = 4 cm**
   - Position (4, 1, 0)
   - Position (4, 1, 3)
   - Position (4, 1, 6)
   - Position (4, 1, 9)
2. **External positions in plane Z = 3 cm**
   - Position (3, 2, 0)
   - Position (3, 2, 3)
   - Position (3, 2, 6)
   - Position (3, 2, 9)
3. **Central position in plane Z = 1 cm**
   - Position (1, 0, 0)



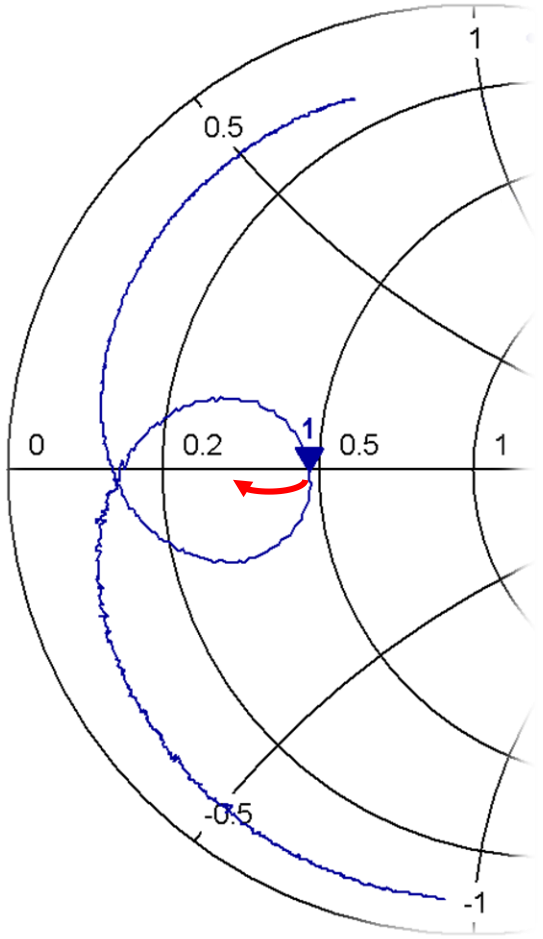
# EMV L1 Analog - Power tests

## Debugging hints



### Problem 1: Lack of voltage at certain position

1. Make sure that the PN5180 is working in gear 0 at full power:
   - Check DPC_CURRENT_GEAR in register RF_STATUS (1Dh)
2. Reduce the impedance to drive more current to the antenna
   - Check that transmitter current does not exceed the limit !!
3. Evaluate changes in antenna design (add ferrite, change antenna position...)




### Problem 2: Voltage measured over the limit at certain position

1. Use a lower power configuration for that particular gear



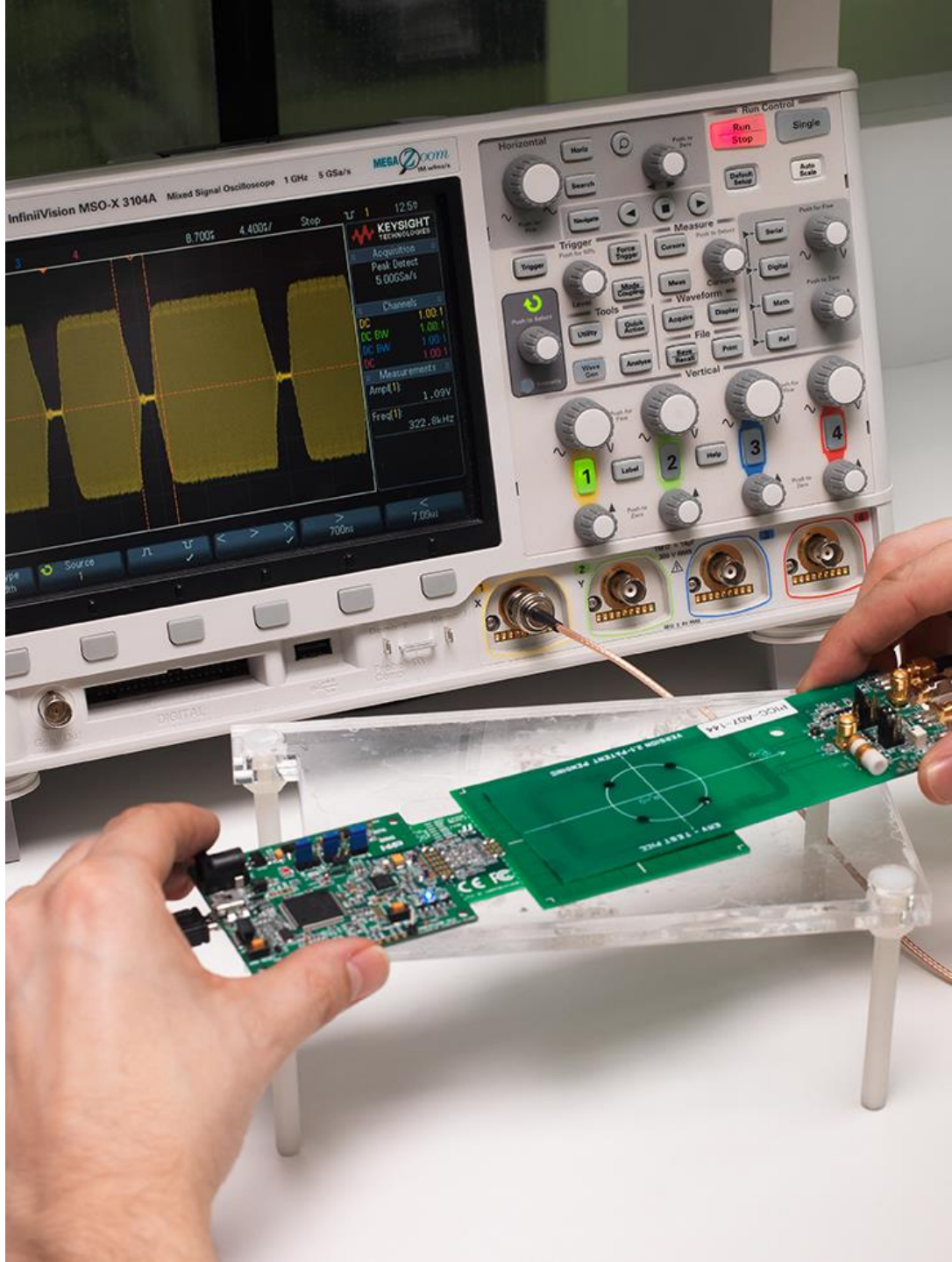
Training Mobile Knowledge

# EMV L1 Analog Waveform tests

# EMV L1 Analog - Waveform tests

## Content

- Evaluation tools
- Test setup
- Performing tests
- Debugging hints






Training Mobile Knowledge

# EMV L1 Analog - Waveform tests

## Evaluation tools



### Option 1

**EMVCo Analog L1 Testbench**

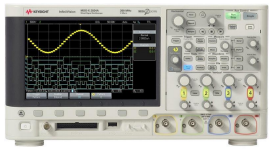

### Option 2

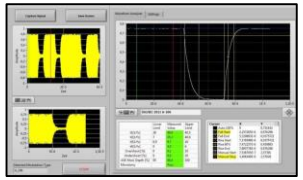
**Reference PICC + Oscilloscope + Evaluation SW**

**Suggestion:**

**CETECOM Wavechecker SW**

PC tool that takes screenshots from the oscilloscope, reads the data, checks the pulse shapes and compares it with the EMV limits.



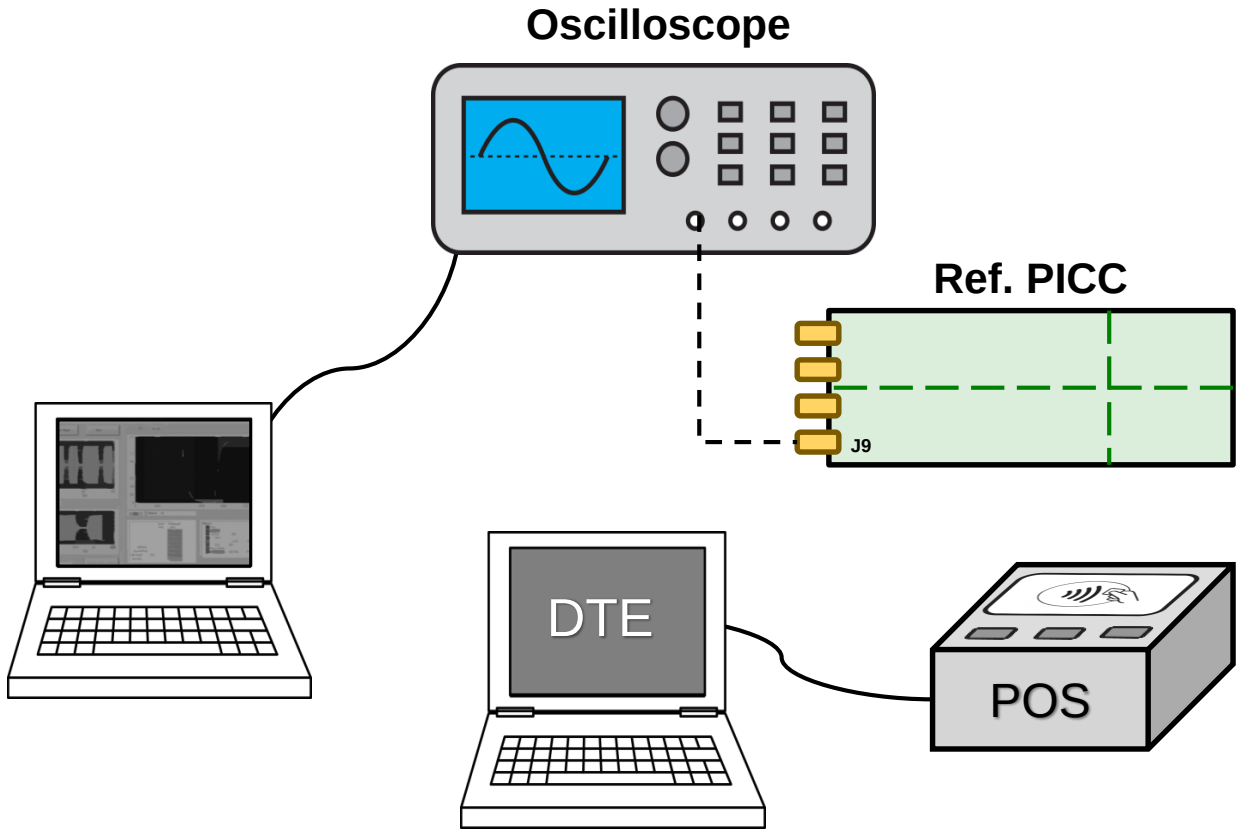


# EMV L1 Analog - Waveform tests

## Test setup



1. Connect J9 of ref PICC to oscilloscope Ch1
2. Set ref PICC J8 in fixed load mode (1-4)
3. Configure oscilloscope trigger to capture modulation
4. Set the DTE in loopback mode



# EMV L1 Analog - Waveform tests

## Debugging tests

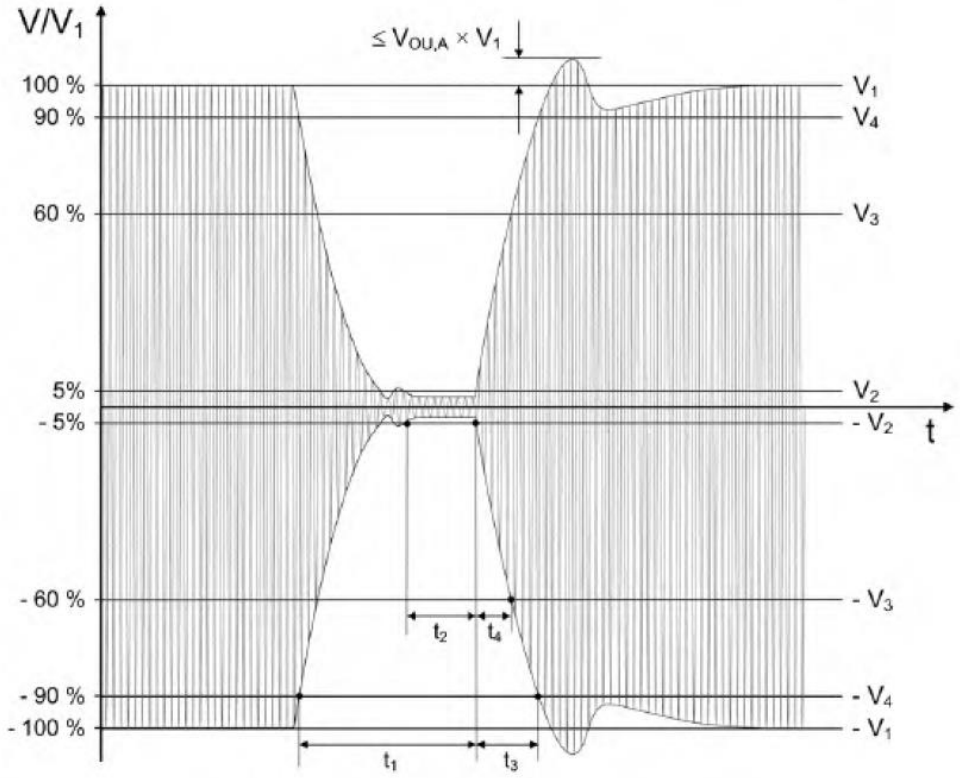


**Type A:**

- TA121: $t_1$
- TA122: Monotonic Decrease
- TA123: Ringing
- TA124: $t_2$
- TA125: $t_3$ and $t_4$
- TA127: Monotonic Increase
- TA128: Overshoot

**PN5180 Relevant parameters:**

- TX_CLK_MODE_RM (RF_CONTROL_TX_CLK)
- Rise and Fall times (RF_CONTROL_TX)
- Overshoot prevention



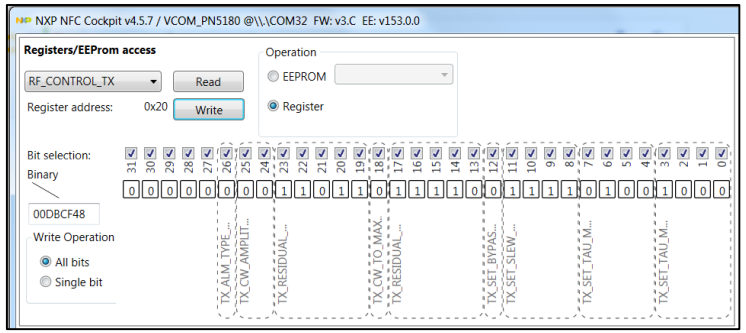
# EMV L1 Analog - Waveform tests

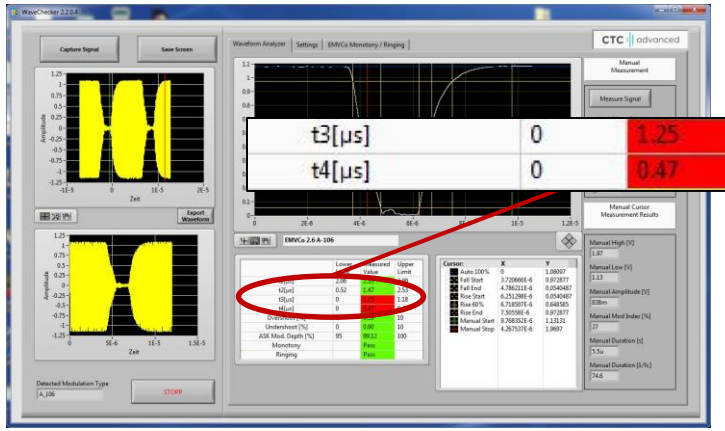
## Debugging tests



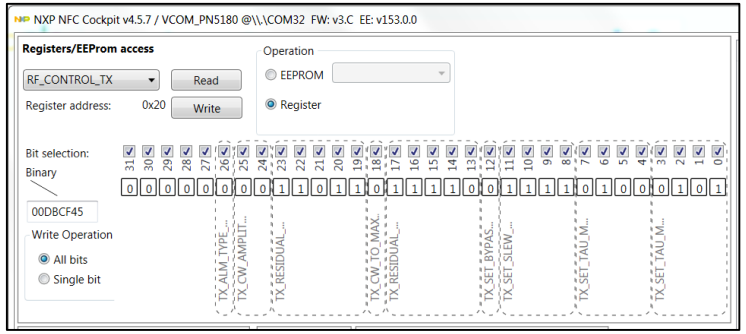
**Type A:**

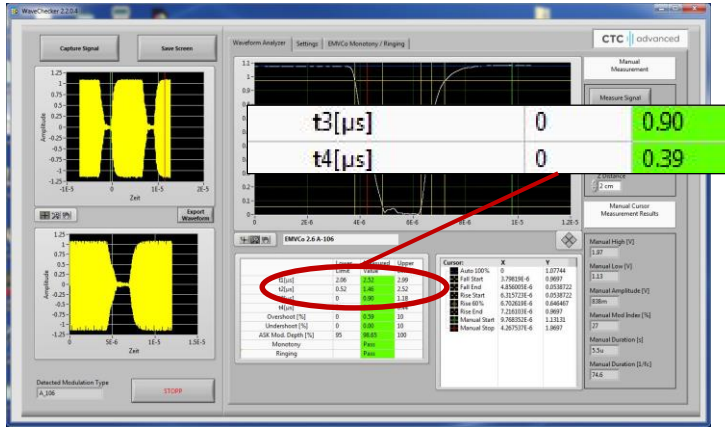
- TA121: $t_1$
- TA122: Monotonic Decrease
- TA123: Ringing
- TA124: $t_2$
- **TA125: $t_3$ and $t_4$**
- TA127: Monotonic Increase
- TA128: Overshoot




Decrease TAU_MOD_RISING






Training Mobile Knowledge

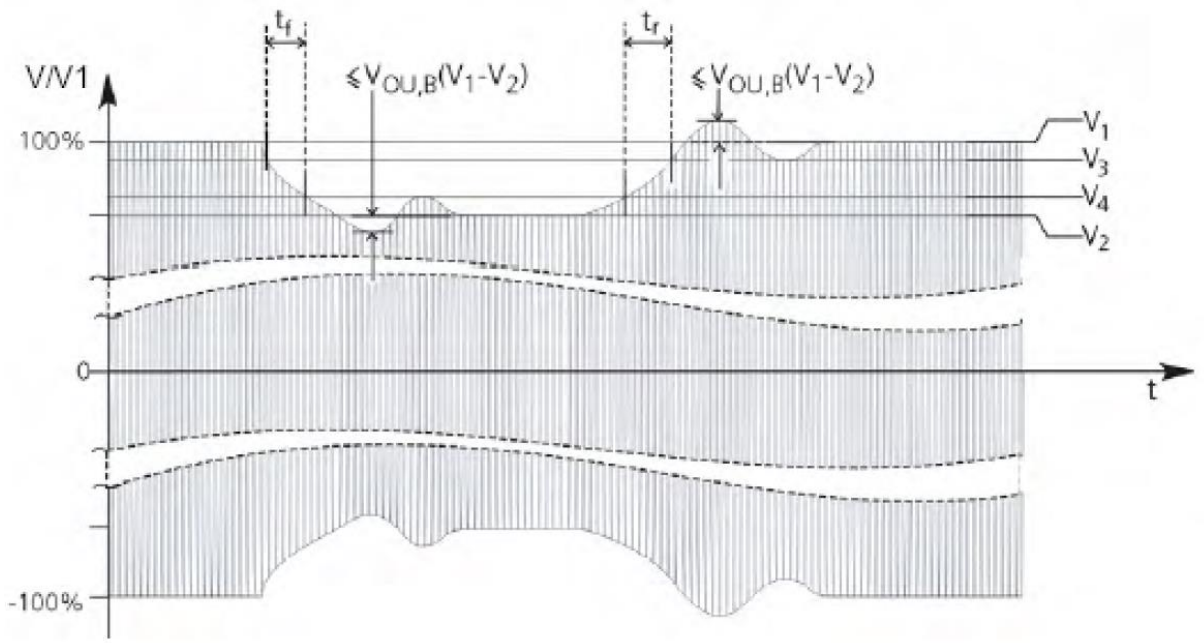
# EMV L1 Analog - Wave shape tests

## Waveform tests



**Type B:**

- TB121: Modulation Index
- TB122: Fall time
- TB123: Rise time
- TB124: Monotonic Increase
- TB125: Monotonic Decrease
- TB126: Overshoots
- TB127: Undershoots




**Relevant PN5180 parameters:**

- TX_RESIDUAL_CARRIER  (RF_CONTROL_TX)
- TX_CLK_MODE_RM (RF_CONTROL_TX_CLK)
- TX_UNDERSHOOT_CONFIG
- TX_OVERSHOOT_CONFIG

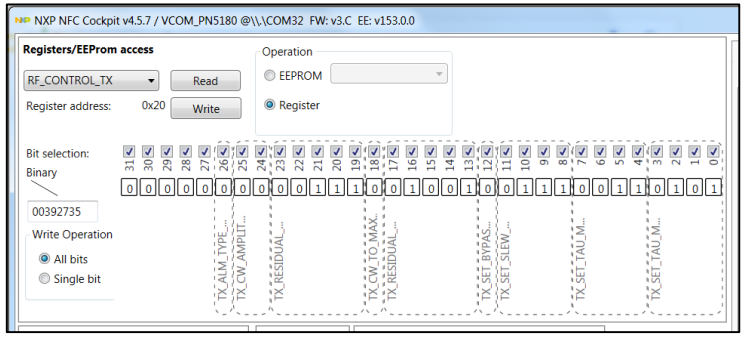
# EMV L1 Analog - Waveform tests

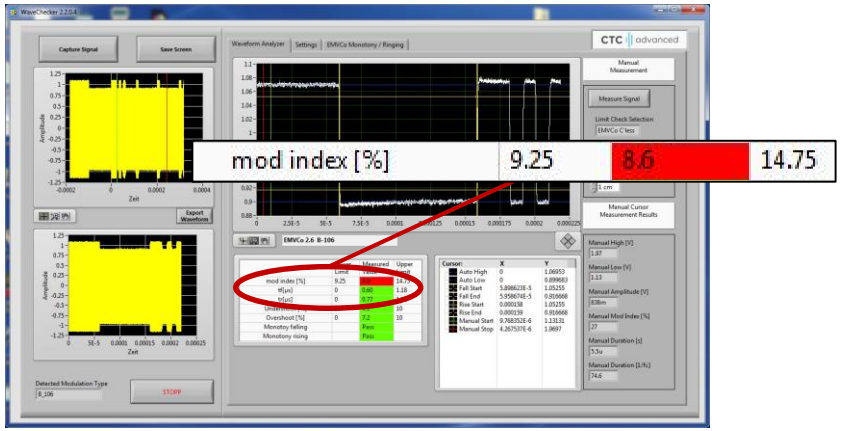
## Debugging tests



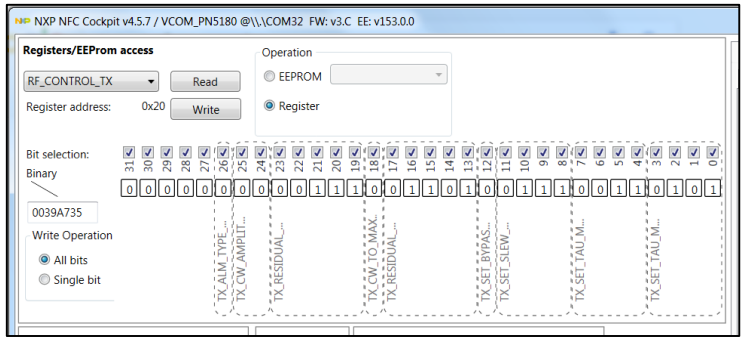
### Type B:

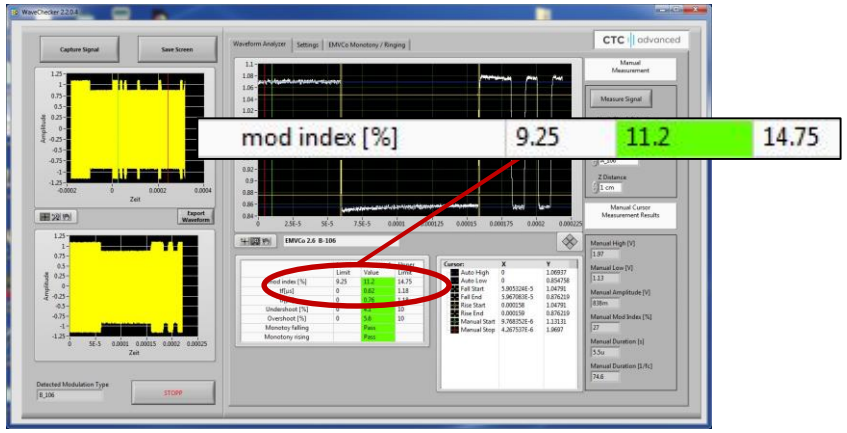
- **TB121: Modulation Index**
- TB122: Fall time
- TB123: Rise time
- TB124: Monotonic Increase
- TB125: Monotonic Decrease
- TB126: Overshoots
- TB127: Undershoots




Increase TX_RESIDUAL_CARRIER



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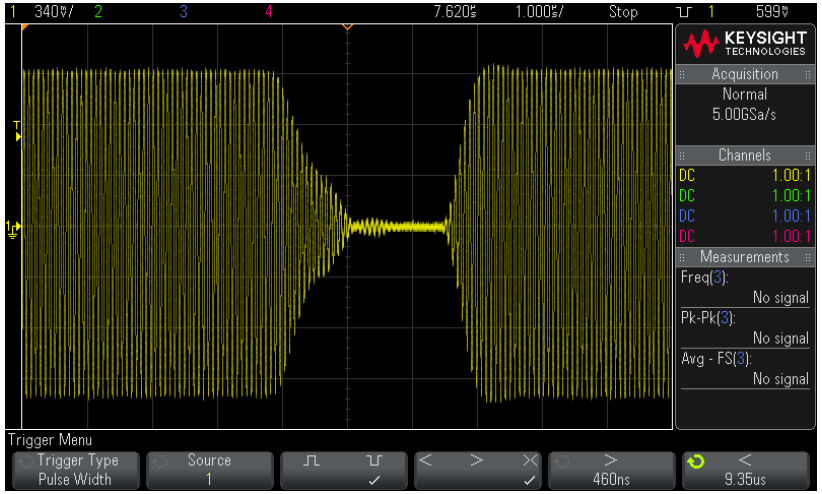
# EMV L1 Analog - Waveform tests

## Debugging tests

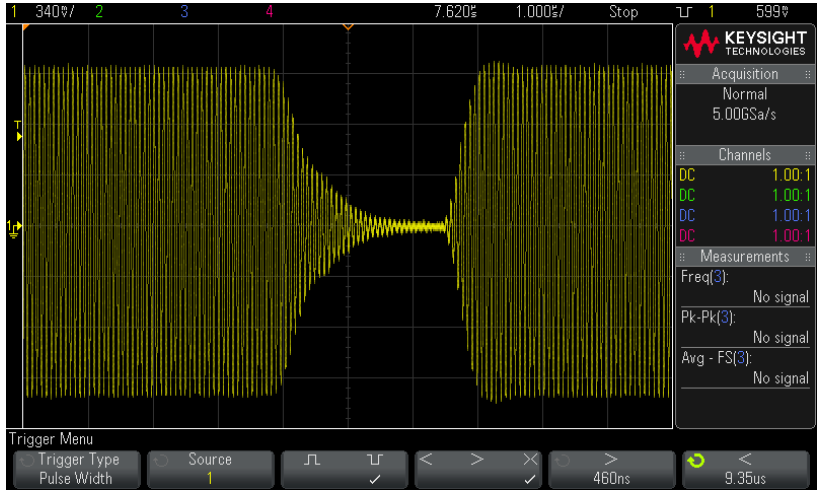


### Other relevant PN5180 parameters

**TX_CLK_MODE_RM**




*TX_CLK_MODE_RM = $001_{BIN}$*




*TX_CLK_MODE_RM = $101_{BIN}$*



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# EMV L1 Analog - Waveform tests

## Debugging tests



### Adaptative Waveform Control (AWC)

PN5180 functionality that allows the device manufacturer to set different register parameters depending on the gear and the protocol used.

Parameters included:

- TX_TAU_MOD_FALLING
- TX_TAU_MOD_RISING
- TX_RESIDUAL_CARRIER

**Example of AWC configuration for Type B**

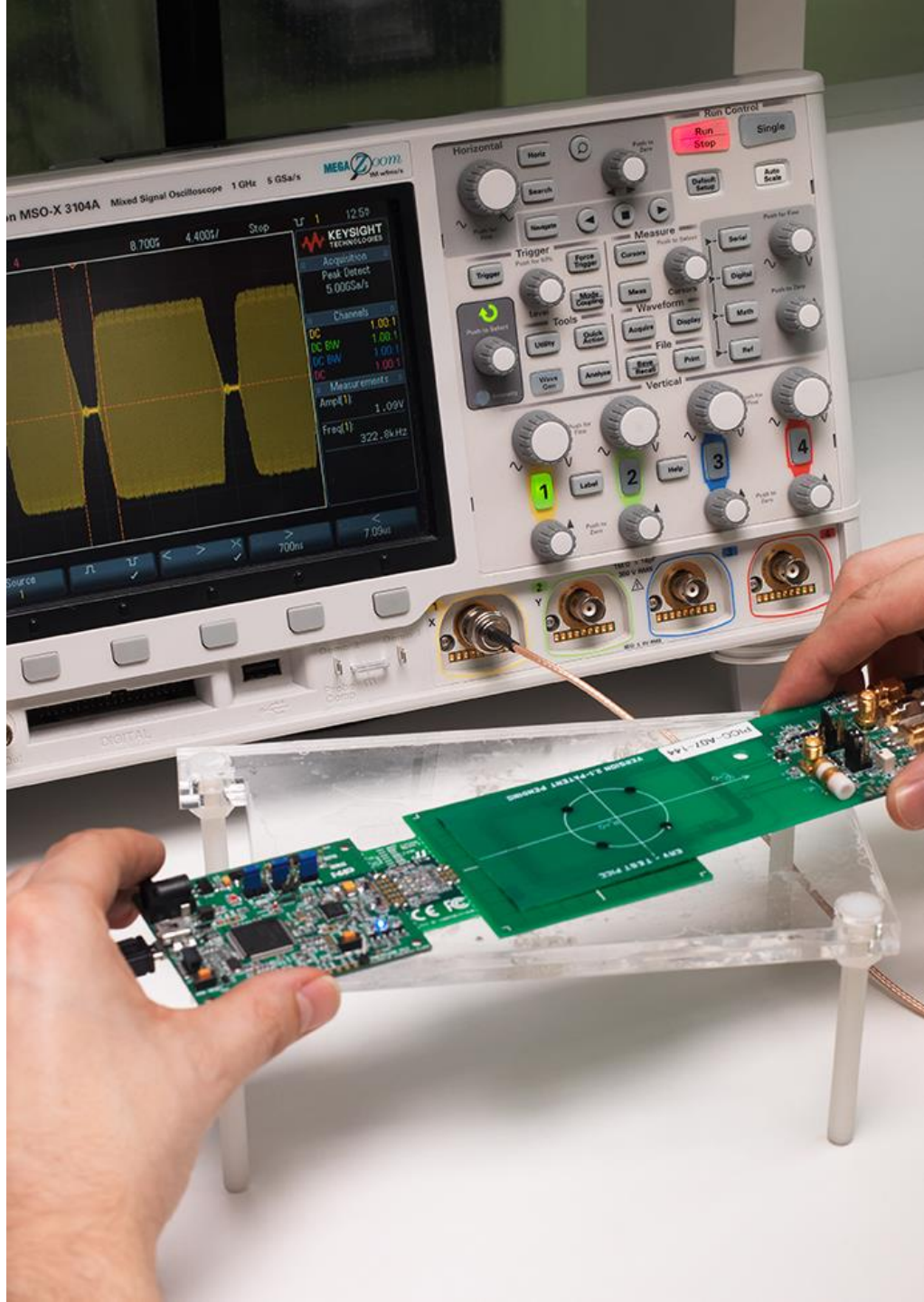
| Parameter | Gear 0 | Gear 1 | Gear 2 | Gear 3 |
|---|---|---|---|---|
| TX_RES_CARRIER | 18 | 18 | 14 | 14 |
| MOD_FALLING | 5 | 3 | 3 | 3 |
| MOD_RISING | 5 | 6 | 6 | 6 |

# EMV L1 Analog Reception tests

# EMV L1 Analog - Reception tests

## Content

- Evaluation tools
- Test setup
- Performing tests
- Debugging hints



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# EMV L1 Analog – Reception tests

## Evaluation tools



### Option 1

**EMVCo Analog L1 Testbench**


### Option 2

**Reference PICC + Waveform Generator + Evaluation SW**

**Suggestion:**

**CETECOM Wave Player SW**

PC tool that uses the waveform generator to inject the modulated responses into the reference PICC.




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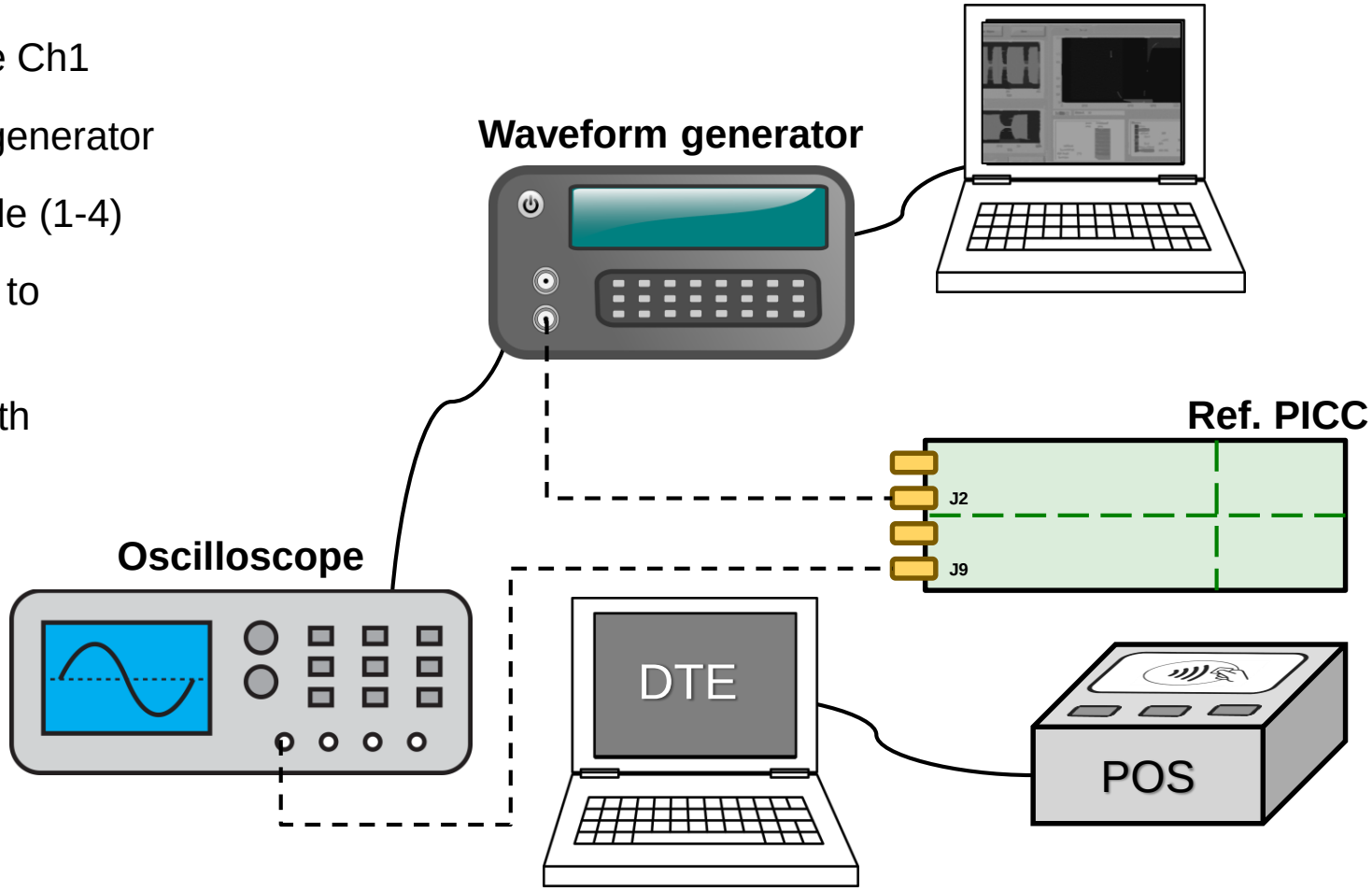
# EMV L1 Analog - Reception tests

## Test setup



1. Connect J9 of ref PICC to oscilloscope Ch1
2. Connect J2  of ref PICC to waveform generator
3. Set ref PICC J8 in non-linear load mode (1-4)
4. Connect Ext.Trigger from oscilloscope to waveform generator
5. Connect waveform generator to PC with CETECOM SW



# EMV L1 Analog – Reception tests

## Performing tests



### Reception tests:

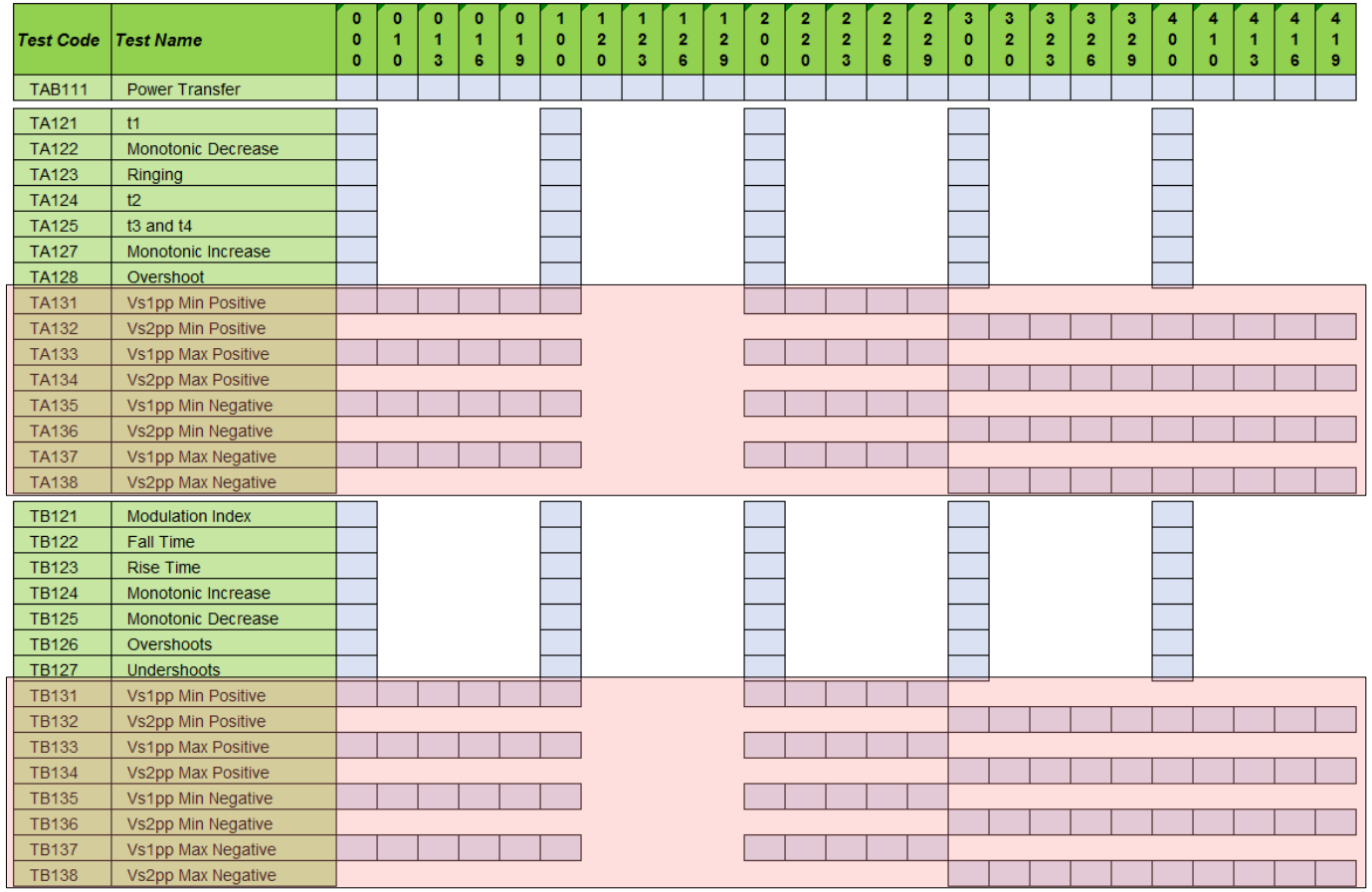
- Tx131: Minimum positive modulation
- Tx133 - Maximum positive modulation
- Tx135 - Minimum negative modulation
- Tx137 - Maximum negative modulation

### Relevant PN5180 parameters:

- RX_GAIN (RF_CONTROL_RX)
- RX_HPCF (RF_CONTROL_RX)
- MIN_LEVEL (SIGPRO_RM_CONFIG)
- MIN_LEVELP (SIGPRO_RM_CONFIG)

### Procedure:

- Use WavePlayer to select amplitude and polarity of the response
- Check that response is correctly received



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# EMV L1 Analog – Reception tests

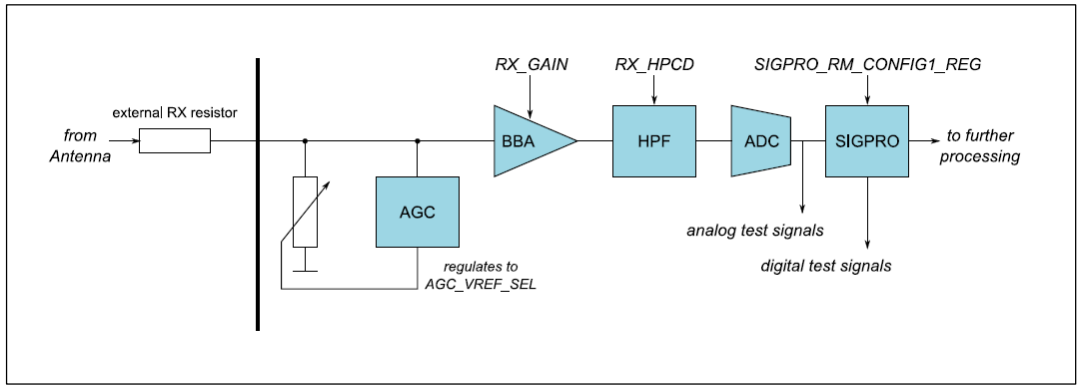
## Debugging hints



**Debugging procedure:**

- Change reception parameters to find a good value
- Change Rx resistor:
  - Decrease resistor to increase sensibility

*PN1580 Receiver block diagram*




*PN1580 Receiver filter characteristics*

| RF_CONTROL_RX Low nibble | rcv_gain | rcv_hpcf | HPCF (kHz) | LPCF (MHz) | Gain (dB20) | Bandwidth (MHz) |
|---|---|---|---|---|---|---|
| 3 | 03 | 00 | 39 | 3.1 | 60 | 3.1 |
| 7 | 03 | 01 | 78 | 3.2 | 59 | 3.1 |
| B | 03 | 02 | 144 | 3.5 | 58 | 3.3 |
| F | 03 | 03 | 260 | 4.1 | 56 | 3.8 |
| 2 | 02 | 00 | 42 | 3.1 | 51 | 3.1 |
| 6 | 02 | 01 | 82 | 3.3 | 51 | 3.2 |
| A | 02 | 02 | 150 | 3.7 | 49 | 3.5 |
| E | 02 | 03 | 271 | 4.3 | 47 | 4.0 |
| 1 | 01 | 00 | 41 | 3.7 | 43 | 3.7 |
| 5 | 01 | 01 | 82 | 4.0 | 42 | 3.9 |
| 9 | 01 | 02 | 151 | 4.5 | 41 | 4.3 |
| D | 01 | 03 | 276 | 5.5 | 39 | 5.2 |
| 0 | 00 | 00 | 42 | 3.8 | 35 | 3.8 |
| 4 | 00 | 01 | 84 | 4.1 | 34 | 4.0 |
| 8 | 00 | 02 | 154 | 4.7 | 33 | 4.5 |
| C | 00 | 03 | 281 | 5.7 | 31 | 5.4 |

# EMV L1 Analog - Reception tests

## Debugging hints



### Adaptative Receiver Control (ARC)

PN5180 functionality that allows the use of different receiver configurations depending on the gear and the protocol used.

Parameters included:

- RX_GAIN
- RX_HPCF
- MIN_LEVEL
- MIN_LEVELP

Example of ARC configuration for Type B

| Parameter | Gear 0 | Gear 1 | Gear 2 | Gear 3 |
|---|---|---|---|---|
| MIN_LEVEL | 3 | 2 | 2 | 2 |
| MIN_LEVEL_P | 8 | 8 | 8 | 8 |
| RX_HPCF | 1 | 0 | 0 | 0 |
| RX_GAIN | 3 | 3 | 2 | 2 |

# EMV L1 Analog - Reception tests

## Debugging hints

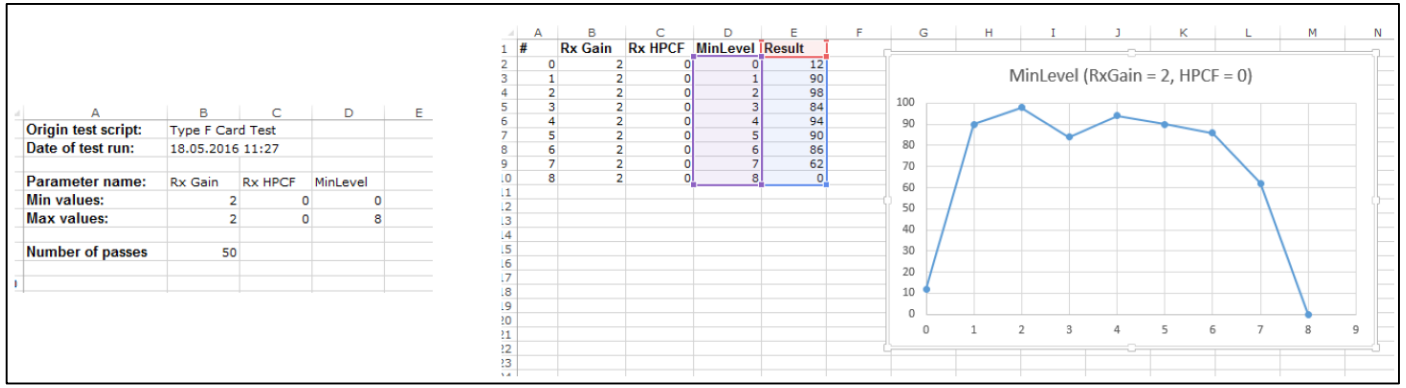


### Rx Matrix tool

Software tool integrated in the NFC Cockpit platform to automatically test different receiver configurations.

Characteristics:

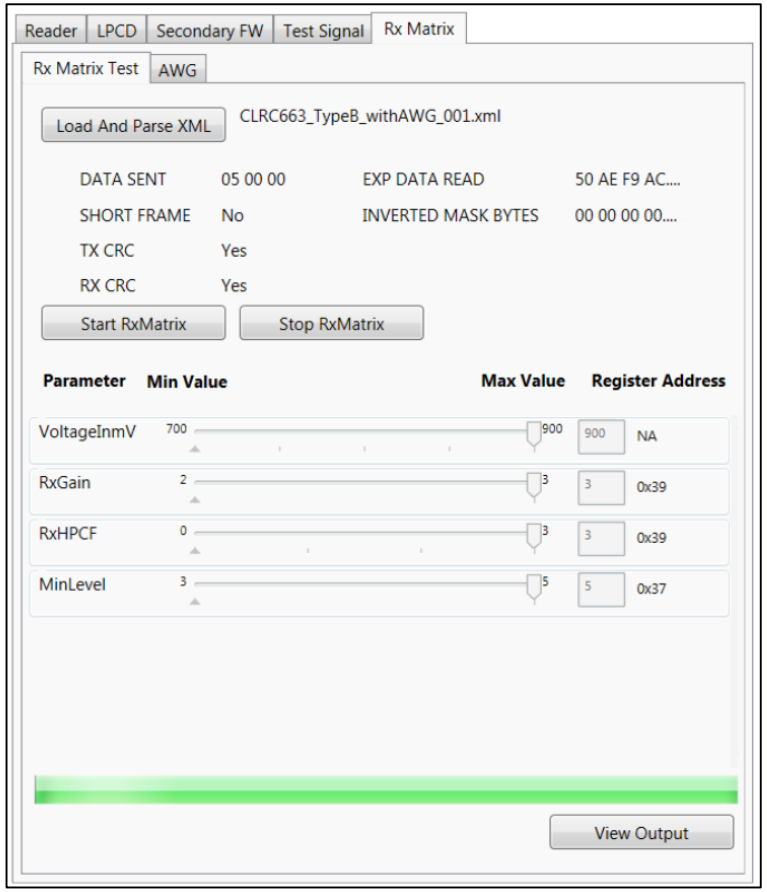
- Can be connected to an AWG to automate the process
- Allows you to select the parameters to change and the range of values
- Select the expected response from the AWG
- Generates a test report with the success ratio for every configuration



| | | | | |
|---|---|---|---|---|
| Origin test script: | Type F Card Test | | | |
| Date of test run: | 18.05.2016 11:27 | | | |
| | | | | |
| Parameter name: | Rx Gain | Rx HPCF | MinLevel | |
| Min values: | 2 | 0 | 0 | |
| Max values: | 2 | 0 | 8 | |
| | | | | |
| Number of passes | 50 | | | |

| # | Rx Gain | Rx HPCF | MinLevel | Result |
|---|---|---|---|---|
| 0 | 2 | 0 | 0 | 12 |
| 1 | 2 | 0 | 1 | 90 |
| 2 | 2 | 0 | 2 | 98 |
| 3 | 2 | 0 | 3 | 84 |
| 4 | 2 | 0 | 4 | 94 |
| 5 | 2 | 0 | 5 | 90 |
| 6 | 2 | 0 | 6 | 86 |
| 7 | 2 | 0 | 7 | 62 |
| 8 | 2 | 0 | 8 | 0 |





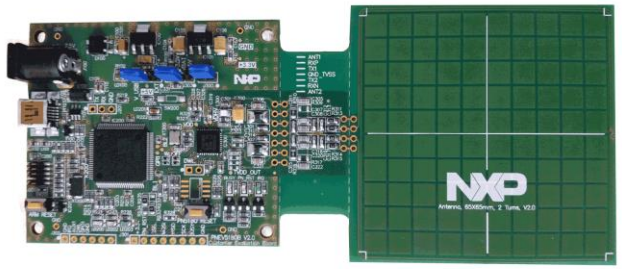


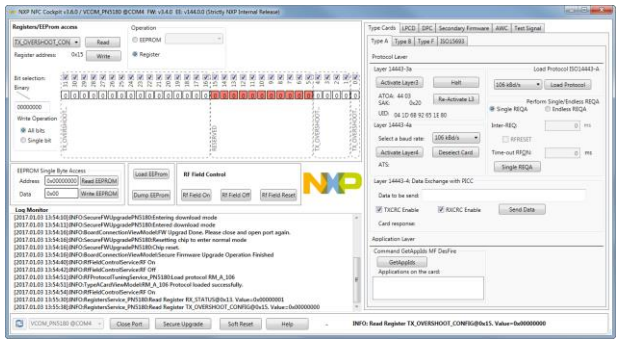

Training Mobile Knowledge

# PN5180 Ecosystem

# PN5180 Ecosystem

## PN5180 Product support package





### PN5180 Demokit

- PN5180 NFC frontend development kit OM25180FDK

### NFC Cockpit

- SW3524 - Installer package PN5180 NFC Cockpit v2.2

### PN5180 Documentation

- PN5180 - Product datasheet
- AN11742 - PN5180 Dynamic Power Control
- AN11744 - PN5180 evaluation board quick start guide
- AN11740 - PN5180 antenna design guide
- AN11741 - How to design an antenna with DPC
- UM10954 - PN5180 SW quick start guide
- SW3545 - PN5180 antenna design tools

### NFC Reader library

- SW3522 - NFC Reader Library for PNEV5180B including all SW examples

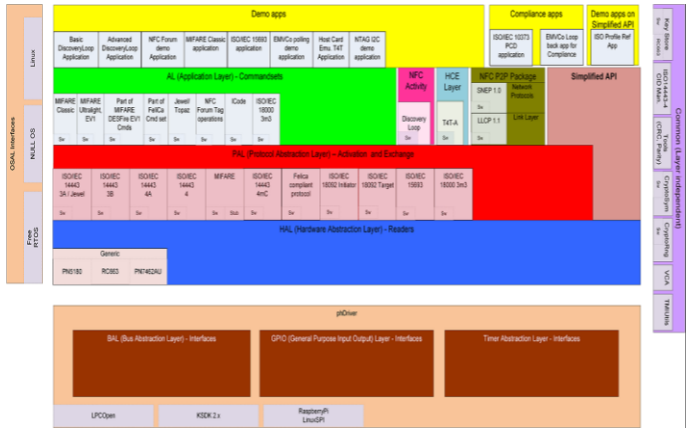


Training Mobile Knowledge

# PN5180 Ecosystem

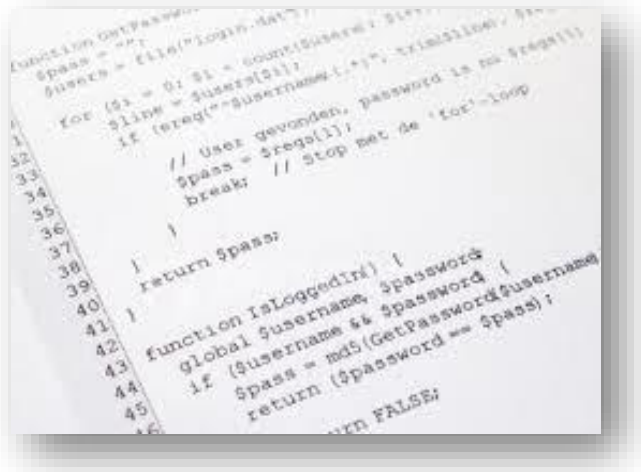
## NFC Reader Library

### NFC Reader Library API




### Documentation


### Software examples



## NFC Reader Library API:

- Freely downloadable.
- Full implementation of all NFC protocols
- NDA version with full support for MIFARE DESFire EV2 and MIFARE Plus EV1
- SW package for MCUXpresso

## Documentation:

- API documentation
- Generated from source file annotations
- Provided as HTML document

## Software examples:

- BasicDiscoveryLoop
- AdvancedDiscoveryLoop
- NFCForum
- ISO15693
- EMVCo Loopback
- ….



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Info and more information: www.nxp.com/pages/:NFC-READER-LIBRARY

# PN5180 Ecosystem

## NFC Reader Library

**Some applications:**

- NfcrdlibSimplifiedAPI_EMVCo → EMVCo digital L1
- NfcrdlibSimplifiedAPI_EMVCo_Analog → EMVCo analog L1

Configuration file: *phNxpNfcRdLib_Config.h*

All parameters involved in the loopback application are well documented and can be changed by user to correctly fit the specifications.

```
/* Default guard times used in Discovery Loop and NFCLIB (Simplified API).
* As per Nfc Forum Activity and EMVCo Specification. */
#define PH_NXPNFCRDLIB_CONFIG_TYPEA_GT                          5100U    /**< Guard time configuration for Type A poll in Micro seconds.*/
#define PH_NXPNFCRDLIB_CONFIG_TYPEB_GT                          5100U    /**< Guard time configuration for Type B poll in Micro seconds.*/
#define PH_NXPNFCRDLIB_CONFIG_TYPEF_GT                          20400U   /**< Guard time configuration for Type F poll in Micro seconds.*/
#define PH_NXPNFCRDLIB_CONFIG_B_TO_F_GT                         15300U   /**< Guard time configuration for Type F poll preceded by Type B poll. */
#define PH_NXPNFCRDLIB_CONFIG_TYPEV_GT                          5200U    /**< Guard time configuration for Type V poll in Micro seconds.*/
#define PH_NXPNFCRDLIB_CONFIG_I18000P3M3_GT                     10000U   /**< Guard time configuration for 18000p3m3 poll in Micro seconds.*/

/* Used in Discovery Loop and NFCLIB (Simplified API) as per EMVCo Specification. */
#define PH_NXPNFCRDLIB_CONFIG_EMVCO_FIELD_OFF_DELAY_US          5100U    /**< Wait time tP as per EMVCo specification. Simplified API EMVCo profile
uses                                                                        this value for Card removal procedure. */
#define PH_NXPNFCRDLIB_CONFIG_EMVCO_REMOVAL_RETRY_COUNT         3U       /**< Poll command retry count used in removal procedure of EMVCo profile. */
```



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Info and more information: www.nxp.com/pages/:NFC-READER-LIBRARY

# More support

# NXP

## Relevant resources regarding POS

| Certification | NXP support | End customer |
|---|---|---|
| **EMVCo L1 contact analog** | Application notes; demo board;<br>Report from test house<br>Customer schematic validation | Final device needs to be tested at a certified lab |
| **EMVCo L1 contact digital** | Application note; source code; ICS example; internal test report<br>Support on NXP stack integration<br>Support on EMV test suite errors | Final device needs to be tested at a certified lab |
| **EMVCo L2 contact** | Link to partners for stack ;<br>Pre integration support if NXP L1 stack is used | Final device needs to be tested at a certified lab |

| Certification | NXP support | End customer |
|---|---|---|
| **EMVCo L1 contactless analog** | Antenna design guide, loop back example; internal test report; demo board<br>Antenna design support & RF support from CAS team | Final device needs to be tested at a certified lab |
| **EMVCo L1 contactless digital** | Source code; application note ICS example; internal test report<br>Support on NXP stack integration<br>Support on EMV test suite errors | Final device needs to be tested at a certified lab |
| **EMVCo L2 contactless** | Link to partners for stack ;<br>Pre integration support if NXP L1 stack is used | Final device needs to be tested at a certified lab |

# MobileKnowledge

## Contact

We are your ideal **engineering consultant** for any specific support in connection with your **POS** developments.

If you want to:

- **Design an EMV POS or mPOS**
- **Select the best performing antenna**
- **Optimize the RF performance of your device**
- **Debug your device to make sure it is EMV L1 compliant**

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# Get ahead with NXP's PN5180 Frontend - Design your POS terminal with EMVCo (L1) certification

## 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

# MobileKnowledge

MobileKnowledge is a team of HW, SW and system engineers, experts in **smart, connected and secure** technologies for the IoT world. We are your ideal **engineering consultant** for any specific support in connection with your **IoT** and **NFC** developments. We design and develop secure HW systems, embedded FW, mobile phone and secure cloud applications.

Our services include:

- **Secure hardware design**
- **Embedded software development**
- **NFC antenna design** and **evaluation**
- **NFC Wearable**
- **EMV L1 pre-certification support**
- **Mobile** and **cloud application development**
- **Secure e2e system design**

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