UM11899

PN5190 automatic DPC calibration

Rev. 1.0 — 6 August 2024 User manual

Document information

Information	Content
Keywords	PN5190, dynamic power control, DPC, automatic DPC calibration
Abstract	This document introduces three small PC executables, which can be used to automatically generate and load a DPC current reduction look up table into the PN5190. Two of the three tools use a cilab ci230 EMVCo test bench including a robot to execute the EMVCo power transfer measurement.

1 Introduction

The PN5190 Dynamic Power Control (DPC) is a powerful tool to control field strength versus PICC loading. However, it requires a proper calibration for a new antenna design.

Note: *For device-specific information, refer to the data sheet of the PN5190 variant in use (PN5190B1 [1], PN5190B2 [2]). For more information, refer to the product page on nxp.com [3].*

1.1 Manual DPC calibration

The DPC calibration can be performed manually. For large antennas, which are not critical, the NFC Cockpit (see [4]) provides a simple method to measure seven VDDPA steps and prepare the current reduction lookup table (LUT). Then only the missing LUT entries must be interpolated to fill the complete LUT. Find instructions in section 5.4 “PN5190 DPC calibration” of [5].

Especially for small antennas, it is highly recommended to measure all 43 VDDPA steps to generate the best input for the driver current reduction LUT, and use the *NXP-NFC-Reader-PN5190-DPC-LUT-Calibration.xlsx* (see [6]) to generate the LUT. For more details, refer to section 5.4.2.2 “NFC Cockpit current reduction calibration accurate method” of [5]. This method is very precise, but the manual measurement and manual programming takes a bit of time and carries the risk of entering incorrect values in the LUT during the process.

1.2 Automatic DPC calibration

NXP provides three small PC tools, which support automatic DPC calibration to simplify and speed up the process:

1. *measure_vov.exe*
2. *measure_dpc_table.exe*
3. *program_dpc_table.exe*

No additional SW installation is required, but is required to have:

- the PN5190 hardware connected to the PC, prepared with VCOM-interface.
- the cilab ci230 EMVCo test bench up and running, which controls a robot to execute the EMVCo power transfer measurement (for the first two tools).

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2 HW and SW prerequisites

On the same PC, the following tools must be properly installed for automatic DPC calibration:

1. Cilab test tool ci230 for EMVCo debug tests (including TestPICC1)
   a. This tool must be up and running as for a standard EMVCo L1 test.
   b. A robot must be connected to the PC and controlled by the cilab tool.
2. PN5190 hardware with VCOM
   a. The VCOM interface is used to connect the PN5190 to the NFC Cockpit.
   b. NXP provides the NFC Cockpit VCOM source code, see [7]
   c. The NFC Cockpit must work with the connected PN5190, but for the automatic DPC calibration the NFC Cockpit must be “disconnected” (since the COM port is used by the automatic DPC calibration tools).
   d. Figure 1 shows the example of a connected PNEV5190BP, using the COM18.

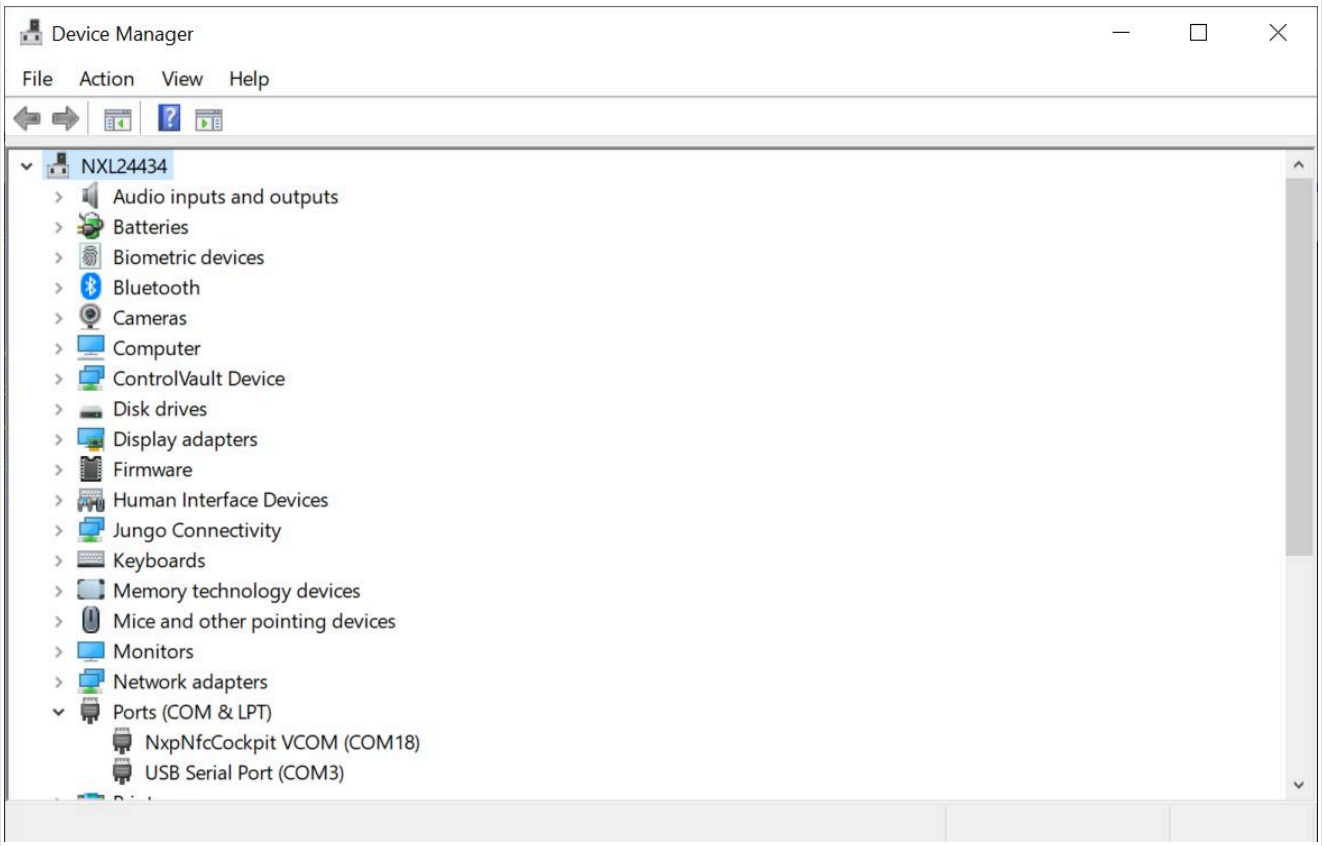

Figure 1. Device manager: PN5190 COM port

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3 Tool description

All three tools and the .xlsx sheet template shall be unzipped and copied into a new folder. Open a CMD shell in this folder, as shown in Figure 2.

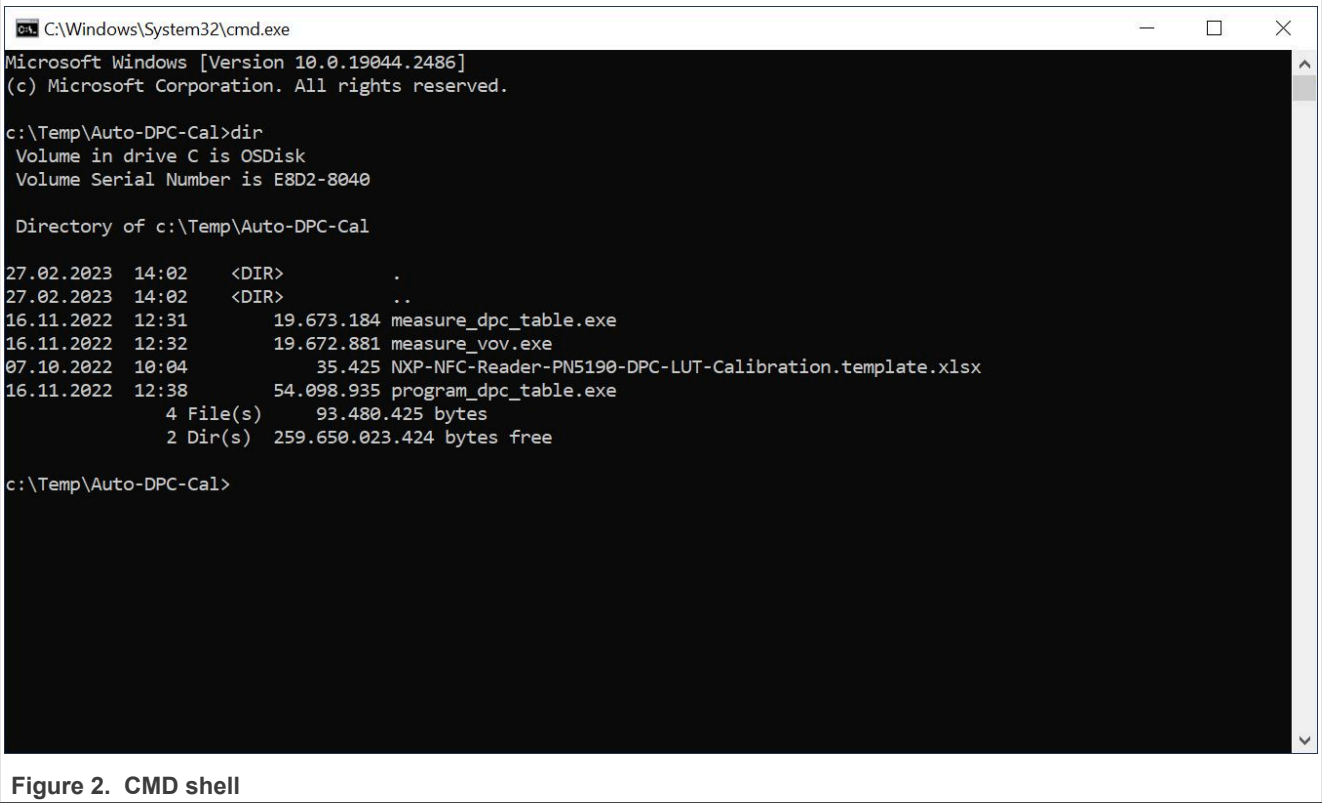

Figure 2. CMD shell

Note: *"<tool_name> --h" starts the help function and shows all parameters of the related tool.*

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3.1 measure_vov.exe

The *measure_vov.exe* simply measures the field strength in the center of the antenna, using the EMVCo Test PICC. The Test PICC is moved from a start position above the center of the antenna down to the center position 000 in steps, and then moves the Test PICC out and back to the start position in small steps. At every step position, the tool measures the DC-level voltage (VoV) of the Test PICC, which is a reference to the field strength (“EMVCo power transfer”), and reads the VDDPA as well as the TX driver current. All results are stored into an excel table.

3.1.1 Preparation before start

Before starting the *measure_vov.exe*, some preparations shall be made:

- The cilab EMVCo test tool must be running and prepared like for analog L1 tests.
- The robot center position (000) must be set properly.
- Cilab tool options:
  - The robot positioning in the cilab tool must be disabled.
  - The power transfer measurement in the cilab analog test options must be set to ”free mode” (i.e. no loopback is required to measure power).
- The PN5190 must be able to run with the NFC Cockpit. The DPC shall be enabled, but the NFC Cockpit itself disconnected.

3.1.2 Usage

The *measure_vov.exe* can be started from the CMD shell. `measure_vov -h` shows the instruction help (see Figure 3).

```
c:\Temp\Auto-DPC-Cal>measure_vov --h
usage: measure_vov [-h] [--log {debug,info,warning,error,critical}] [--com COM] [--ci230 IP[:PORT]] [--z Z]
                   [--step STEP] [--csv CSV] [--xls XLS]

options:
  -h, --help            show this help message and exit
  --log {debug,info,warning,error,critical}
  --com COM             PN5190 EV comport e.g. COM5. If no comport is specified then auto detection is performed
  --ci230 IP[:PORT]     ci230 test suite address
  --z Z                 Z start position (unloaded position)
  --step STEP           Z step (mm)
  --csv CSV             save measurement data to CSV file
  --xls XLS             save measurement data to Excel file
```

Figure 3. measure_vov --h

3.1.3 Example

```
measure_vov --com COM6 --z 60 --step 1 --xls Fieldstrength_measured.xls
```

The command starts the measurement at 60 mm above the 000 position, and then steps down to 0 mm in steps of 1 mm. After reaching the 000 position, the measurement continues and steps up again back to 60 mm in steps of 1 mm. For each step, the VoV (= field strength equivalent), the VDDPA and the TX driver current are saved.

The complete results of the measurement is saved in the *Fieldstrength_measured.xls* file. The Figure 5 shows a typical measurement of a working DPC, as a result from the first two columns of the *Fieldstrength_measured.xls* in a simple XY diagram (VoV in V versus distance in mm). The required hysteresis can be clearly seen, showing results in different VoV values between moving in and out of the field.

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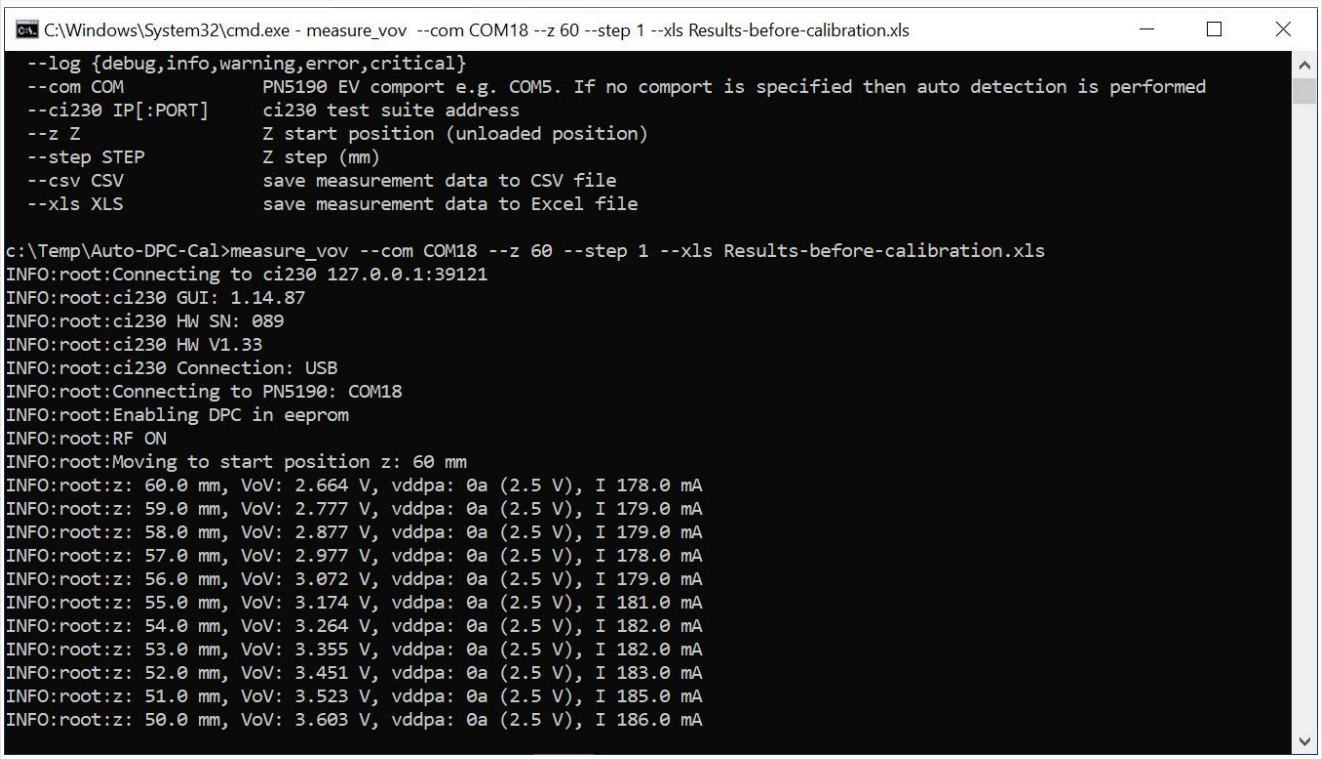

Figure 4. Start of measure_vov.exe

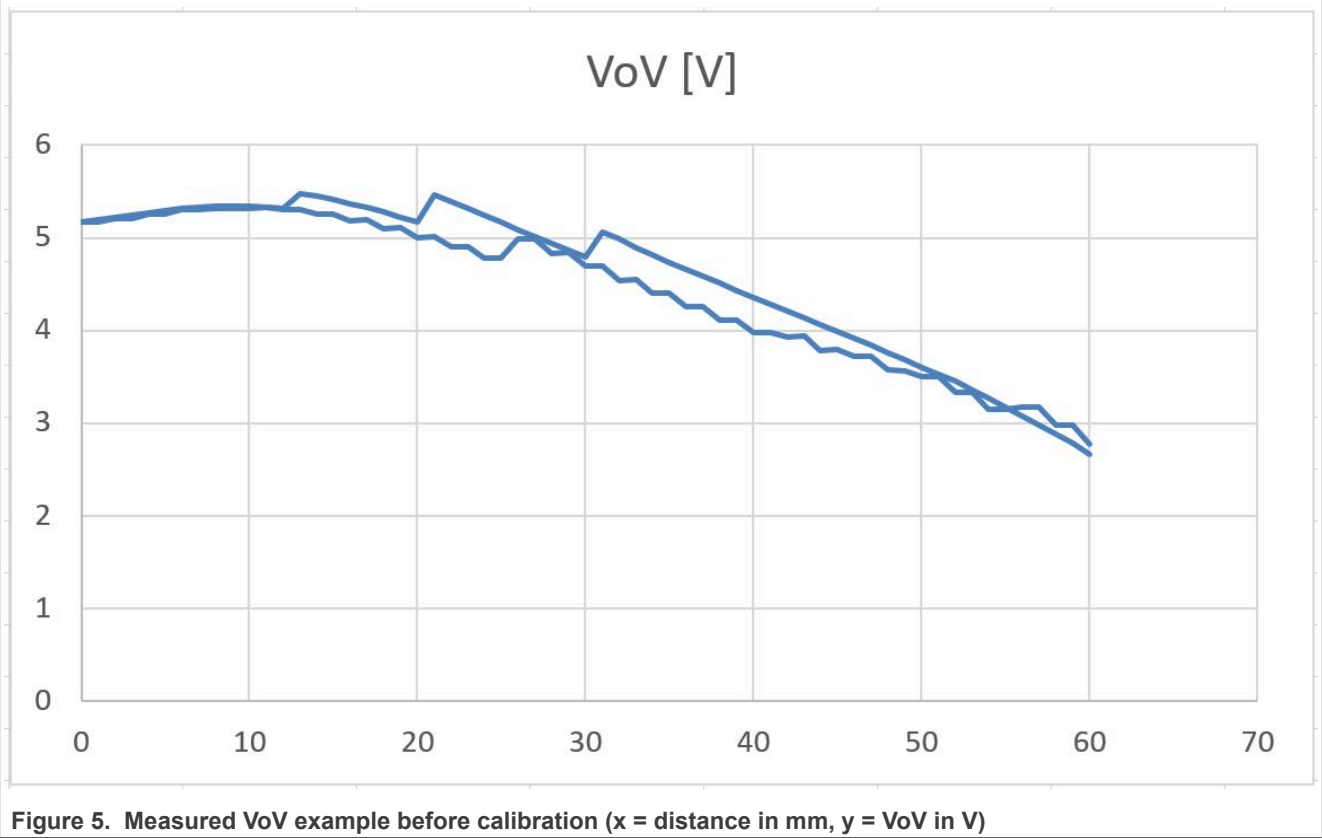

Figure 5. Measured VoV example before calibration (x = distance in mm, y = VoV in V)

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3.2 measure_dpc_table.exe

The *measure_dpc_table.exe* automatically measures the DPC calibration table and fills the *NXP-NFC-Reader-PN5190-DPC-LUT-Calibration.template.xlsx* file. The EMVCo Test PICC is used, the usage of Test PICC1 is recommended.

The tool can disable the DPC (as required for calibration), and then moves the Test PICC from a defined start position above the center of the antenna down to the center position 000 in small steps. At the start position, the tool applies the VDDPA = 5.7 V, which drives the maximum available power.

At every step position, the tool measures the DC voltage level (VoV) of the Test PICC, which is a reference to the field strength (or EMVCo Power transfer), and it reads the TX driver current. When the VoV exceeds the defined target VoV in a position, the tool reduces the VDDPA by 100 mV. For each VDDPA level, the tool saves the related VoV and the related TX driver current, which corresponds to the required power level to achieve this defined target VoV in a certain position.

All the results are stored into an excel table, using the *NXP-NFC-Reader-PN5190-DPC-LUT-Calibration.template.xlsx*.

3.2.1 Preparation before start

Before starting the *measure_dpc_table.exe*, some preparations shall be made:

- The cilab EMVCo test tool must be running and prepared like for analog L1 tests.
- The robot center position (000) must be set properly.
- Cilab tool options:
  - The robot positioning in the cilab tool must be disabled.
  - The power transfer measurement in the cilab analog test options must be set to ”free mode” (i.e. no loopback is required to measure power).
- The PN5190 must be able to run with the NFC Cockpit. The DPC shall be enabled, but the NFC Cockpit itself disconnected.

3.2.2 Usage

The *measure_dpc_table.exe* can be started from the CMD shell. `measure_dpc_table -h` shows the instruction help (see Figure 6).

```
c:\Temp\Auto-DPC-Cal>measure_dpc_table --h
usage: measure_dpc_table [-h] [--log {debug,info,warning,error,critical}] [--com COM] [--ci230 IP[:PORT]]
                         [--disable-dpc] [--z Z] [--step STEP] [--vov VOV] [--csv CSV] [--xls XLS]

options:
  -h, --help            show this help message and exit
  --log {debug,info,warning,error,critical}
  --com COM             PN5190 EV comport e.g. COM5. If no comport is specified then auto detection is performed
  --ci230 IP[:PORT]     ci230 test suite address
  --disable-dpc         Disable DPC in EEPROM
  --z Z                 Z start position (unloaded position)
  --step STEP           Z step (mm)
  --vov VOV             Target VoV value
  --csv CSV             save measurement data to CSV file
  --xls XLS             save DPC LUT to excel file
```

Figure 6. measure_dpc_table --h

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3.2.3 Example

```
Measure_dpc_table --com COM6 --disable-dpc --z 60 --step 1 --vov 5.8 --xls DPC-
Calibration.xls
```

The above command starts the calibration measurement at 60 mm and uses 1 mm steps. In this example, the PN5190 device (e.g. the PNEV5190BP) is connected to the PC, using the COM port 6.

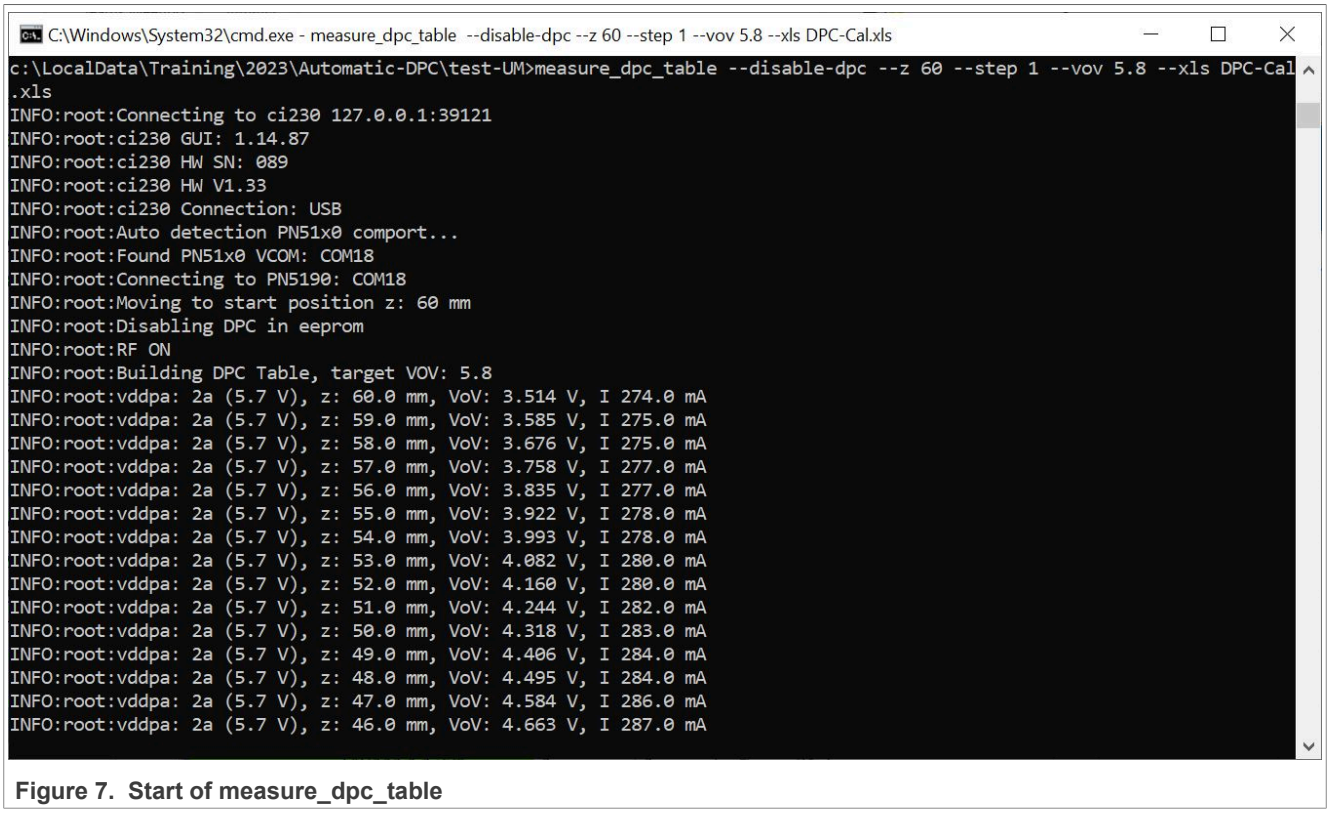

Figure 7. Start of measure_dpc_table

For this measurement, the DPC must be disabled in the EEPROM setting: this can either be done as part of the preparation with the NFC Cockpit upfront, or the tool can do this by using the parameter `--disable-dpc`. The tool automatically re-enables the DPC after the test, if it had been disabled by the parameter `--disable-dpc`.

The target VoV (“power transfer”) in this example is set to 5.8 V, which sits reasonably between the minimum and maximum EMVCo power transfer limits. The measurement results, including the TX driver current reduction proposal values are stored in the *DPC-Calibration.xls*.

Before saving the current reduction LUT, it is required to check the automatic settings and possibly correct some single values to avoid “forbidden” DPC conditions. The excel sheet indicates such “forbidden” settings. In those VDDPA positions, where the “DPC condition is broken”, the TX driver current in column B should be manually increased in mA steps until the condition becomes valid.

Note: *It is also recommended to check all the TX driver current entries in column B. In some cases, the measurement tolerances result in some minor variations, which should be smoothed out.*

Save the checked and smoothed excel sheet when all current (reduction) values are correct.

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3.3 program_dpc_table.exe

The last step is to store the target current and all current reduction LUT entries (including the missing ones, which need to be interpolated) into the PN5190 EEPROM. This can be done with the *program_dpc_table.exe*.

3.3.1 Preparation before start

Before starting the *program_dpc_table.exe*, some preparations shall be made:

- The PN5190 must be able to run with NFC Cockpit. The DPC shall be enabled, but the NFC Cockpit itself disconnected.

3.3.2 Usage

The *program_dpc_table.exe* then can be started from the CMD shell. `program_dpc_table -h` shows the instruction help (see Figure 8).

```
c:\Temp\Auto-DPC-Cal>program_dpc_table --h
usage: program_dpc_table [-h] [--log {debug,info,warning,error,critical}] [--com COM] --xls XLS [--csv CSV]

options:
  -h, --help            show this help message and exit
  --log {debug,info,warning,error,critical}
  --com COM             PN5190 EV comport e.g. COM5. If no comport is specified then auto detection is performed
  --xls XLS             DPC LUT Calibration data excel file
  --csv CSV             Output programmed DPC table to csv file
```

Figure 8. program_dpc_table --h

3.3.3 Example

```
program_dpc_table --com COM6 --xls DPC-Calibration.xls --csv DPC-LUT-programmed.csv
```

The above command stores the previously generated LUT into the PN5190. Missing LUT entries are generated with a simple interpolation and stored. In parallel, all programmed LUT values are saved into a CSV file. The CSV file can be helpful for the design in project documentation.

```
c:\Temp\Auto-DPC-Cal>program_dpc_table --com COM18 --xls Calibrated-DPC-5V7_corrected.xlsx --csv final-LUT.csv
INFO:root:Connecting to PN5190: COM18
INFO:root:Loading DPC table excel file: Calibrated-DPC-5V7_corrected.xlsx
INFO:root:Writing target current reduction: 292
INFO:root:Updating PN5190 DPC table
```

Figure 9. Start of program_dpc_table

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4 Guidance to automatically calibrate the DPC

The following sequence provides step-by-step instructions to run a full DPC calibration with the PN5190 device automatically.

1. Prepare setup
   a. Start ci230 and robot and the cilab GUI.
   b. Place the PCD device into position and adjust (set) the position 000.
   c. Disable <Robot positioning> in cilab options (see Figure 10).
   d. Switch power transfer to “free” in cilab options (see Figure 11.)
   e. Connect PCD to PC, and check the assigned COM port.
2. Optional: Start *measure_vov.exe* in CMD shell.
   a.
   ```
   measure_vov --com COM6 --z 60 --step 1 --xls Fieldstrength_measured.xls
   ```
   b. Check the result.
3. Start *measure_dpc_table.exe* in CMD shell.
   a.
   ```
   measure_dpc_table --com COM6 --disable-dpc --z 60 --step 1 --vov 5.8 --xls DPC-Calibration.xls
   ```
   b. Open result: An example is shown in Figure 12
4. Open the excel sheet *DPC-Calibration.xls* and adjust bad combinations of VDDPA and ITVDD.
   a. Check for “DPC condition broken” and increase the TX driver current in column B, until the condition is ok.
   b. Smooth the TX driver current to reasonable values.
   c. Save the excel sheet: An example is shown in Figure 13.
5. Program the LUT with *program_dpc_table.exe* in the CMD shell.
   a.
   ```
   program_dpc_table --com COM6 --xls DPC-Calibration.xls --csv DPC-LUT-programmed.csv
   ```
   b. Save both excel sheets for documentation.
6. Final: Start *measure_vov.exe* in CMD shell.
   a.
   ```
   measure_vov --com COM6 --z 60 --step 1 --xls Fieldstrength_measured.xls
   ```
   b. Check the result: Example is shown in Figure 14.

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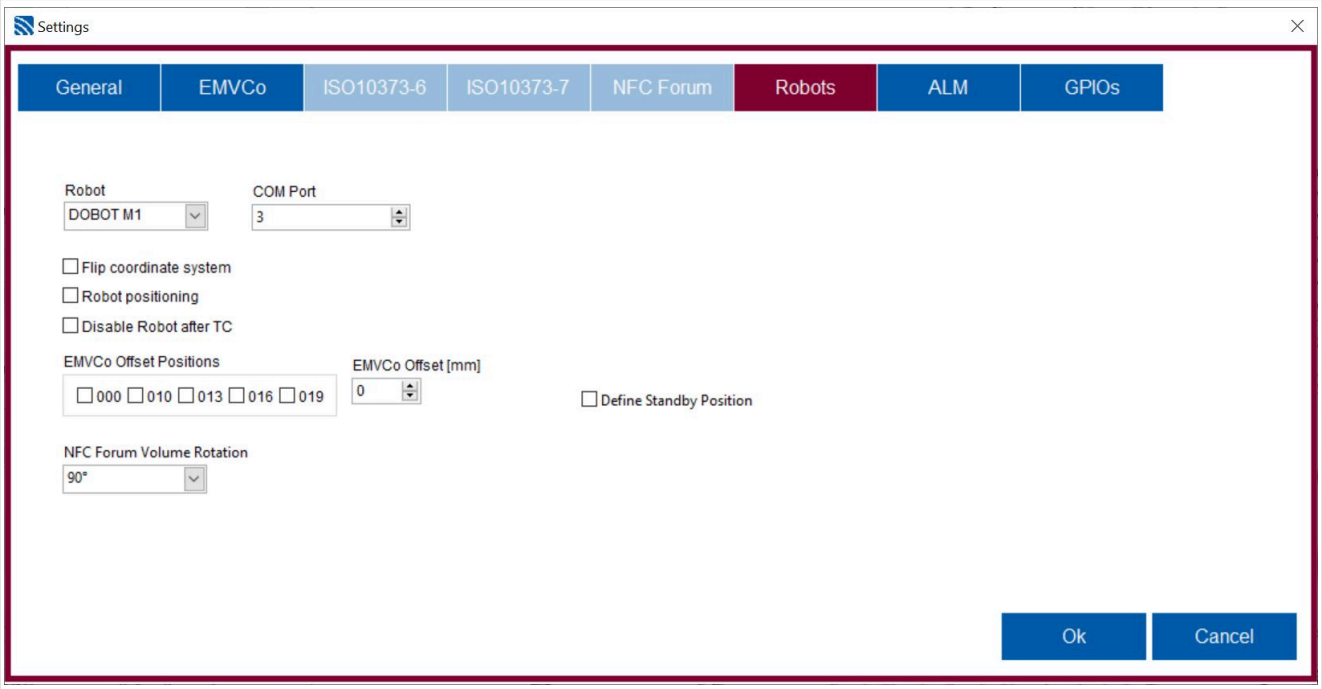

Figure 10. cilab options: Robot positioning

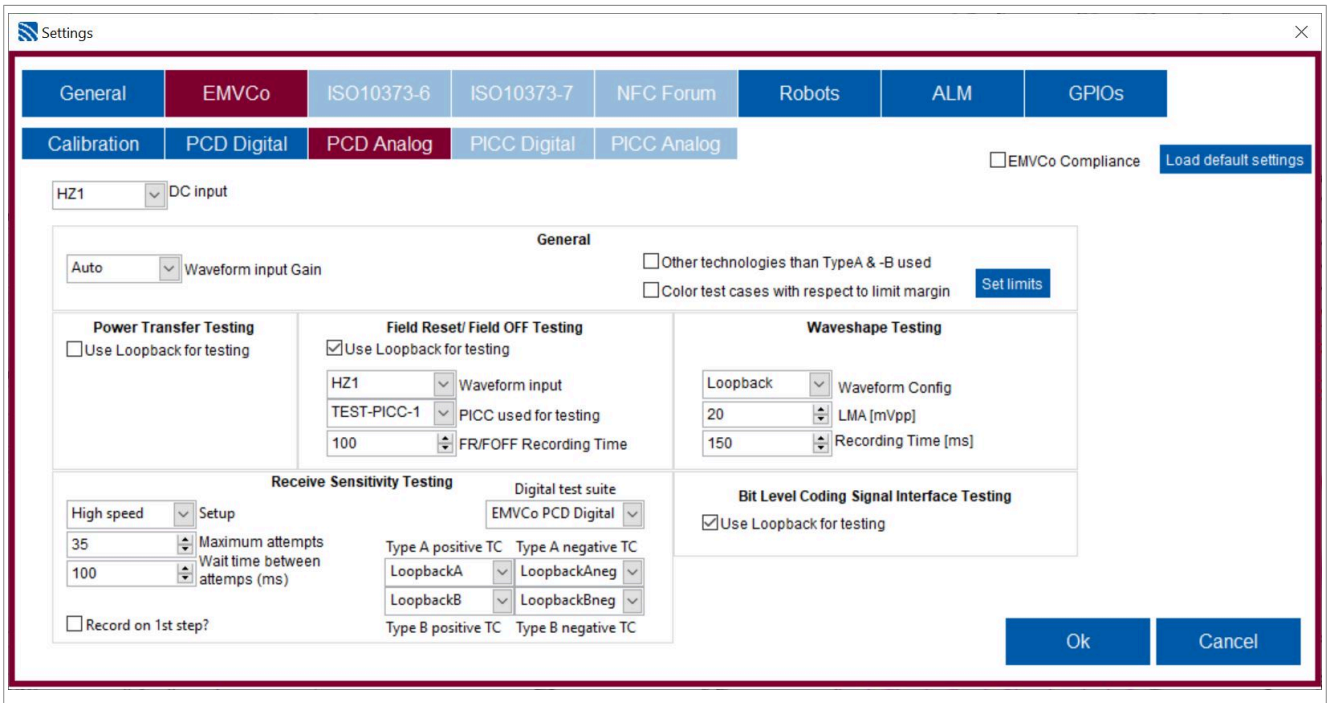

Figure 11. cilab options: power transfer test

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Target current: 298 mA

VDDPA [V]	ITVDD [mA]	Power Transfer [V]	Current reduction [mA]	Total load [Ω]	Warning
5,7	298	5,53	0	19,13	OK
5,6	299	5,53	-1	18,73	Current too high!
5,5	296	5,60	2	18,58	OK
5,4	291	5,55	7	18,56	OK
5,3	286	5,63	12	18,53	OK
5,2	282	5,57	16	18,44	OK
5,1	276	5,52	22	18,48	Current too low!
5,0	275	5,60	23	18,18	OK
4,9	268	5,54	30	18,28	Current too low!
4,8	265	5,61	33	18,11	OK
4,7	261	5,56	37	18,01	OK
4,6	259	5,64	39	17,76	OK
4,5	254	5,57	44	17,72	OK
4,4	248	5,51	50	17,74	Current too low!
4,3	245	5,58	53	17,55	OK
4,2	240	5,51	58	17,50	OK
4,1	239	5,57	59	17,15	OK
4,0	232	5,50	66	17,24	Current too low!
3,9	229	5,56	69	17,03	OK
3,8	228	5,64	70	16,67	OK
3,7	223	5,55	75	16,59	OK
3,6	221	5,61	77	16,29	OK
3,5	216	5,53	82	16,20	OK
3,4	212	5,59	86	16,04	OK
3,3	204	5,51	94	16,18	Current too low!
3,2	203	5,56	95	15,76	OK
3,1	195	5,52	103	15,90	Current too low!
3,0	192	5,56	106	15,62	OK
2,9	192	5,59	106	15,10	OK
2,8	188	5,63	110	14,89	OK
2,7	185	5,52	113	14,59	OK
2,6	184	5,55	114	14,13	OK
2,5	180	5,58	118	13,89	OK
2,4	181	5,58	117	13,26	Current too high!
2,3	181	5,59	117	12,71	OK
2,2	180	5,58	118	12,22	OK
2,1	181	5,59	117	11,60	Current too high!
2,0	176	5,57	122	11,36	OK
1,9	178	5,54	120	10,67	Current too high!
1,8	185	5,60	113	9,73	Current too high!
1,7	184	5,51	114	9,24	OK
1,6	192	5,51	106	8,33	Current too high!
1,5	219	5,53	79	6,85	Current too high!

Current reduction LUT

VDDPA [V]	Current reduction [mA]	hex
5,7	0	0
5,6	-1	FFFFFFFF
5,5	2	2
5,5	2	2
5,5	2	2
5,5	2	2
5,5	2	2
5,4	23	17
5,4	23	17
5,4	23	17
5,3	39	27
5,3	39	27
5,3	39	27
5,2	53	35
5,2	53	35
5,1	59	3B
5,1	59	3B
5,0	70	46
4,9	75	4B
4,9	75	4B
4,8	82	52
4,8	82	52
4,8	82	52
4,7	95	5F
4,7	95	5F
4,7	95	5F
4,5	106	6A
4,4	110	6E
4,3	113	71
4,2	114	72
4,1	118	76
4,0	117	75
3,8	117	75
3,6	118	76
3,5	117	75
3,4	122	7A
3,2	120	78
2,9	113	71
2,8	114	72
2,5	106	6A
2,0	79	4F

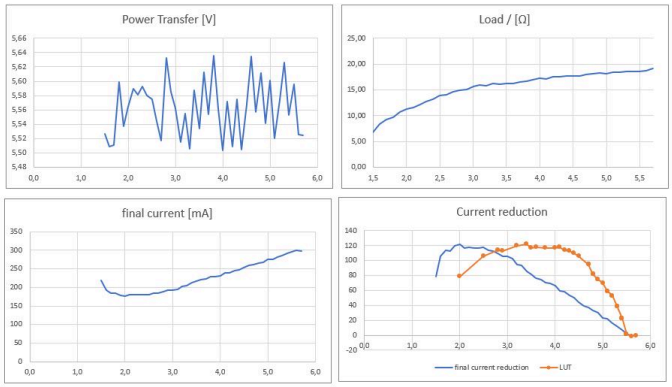

Figure 12. Uncorrected DPC calibration measurement result

Target current: 298 mA

VDDPA [V]	ITVDD [mA]	Power Transfer [V]	Current reduction [mA]	Total load [Ω]	Warning
5,7	298	5,53	0	19,13	OK
5,6	298	5,53	0	18,79	OK
5,5	296	5,60	2	18,58	OK
5,4	291	5,55	7	18,56	OK
5,3	286	5,63	12	18,53	OK
5,2	282	5,57	16	18,44	OK
5,1	277	5,52	21	18,41	OK
5,0	275	5,60	23	18,18	OK
4,9	270	5,54	28	18,15	OK
4,8	265	5,61	33	18,11	OK
4,7	261	5,56	37	18,01	OK
4,6	259	5,64	39	17,76	OK
4,5	254	5,57	44	17,72	OK
4,4	249	5,51	49	17,67	OK
4,3	245	5,58	53	17,55	OK
4,2	240	5,51	58	17,50	OK
4,1	239	5,57	59	17,15	OK
4,0	234	5,50	64	17,09	OK
3,9	229	5,56	69	17,03	OK
3,8	228	5,64	70	16,67	OK
3,7	223	5,55	75	16,59	OK
3,6	221	5,61	77	16,29	OK
3,5	216	5,53	82	16,20	OK
3,4	212	5,59	86	16,04	OK
3,3	206	5,51	92	16,02	OK
3,2	203	5,56	95	15,76	OK
3,1	197	5,52	101	15,74	OK
3,0	192	5,56	106	15,62	OK
2,9	192	5,59	106	15,10	OK
2,8	188	5,63	110	14,89	OK
2,7	185	5,52	113	14,59	OK
2,6	184	5,55	114	14,13	OK
2,5	181	5,58	117	13,81	OK
2,4	181	5,58	117	13,26	OK
2,3	181	5,59	117	12,71	OK
2,2	181	5,58	117	12,15	OK
2,1	181	5,59	117	11,60	OK
2,0	181	5,57	117	11,05	OK
1,9	181	5,54	117	10,50	OK
1,8	181	5,60	117	9,94	OK
1,7	181	5,51	117	9,39	OK
1,6	181	5,51	117	8,84	OK
1,5	181	5,53	117	8,29	OK

Current reduction LUT

VDDPA [V]	Current reduction [mA]	hex
5,7	0	0
5,6	0	0
5,5	2	2
5,5	2	2
5,5	2	2
5,5	2	2
5,5	2	2
5,4	23	17
5,4	23	17
5,4	23	17
5,3	39	27
5,3	39	27
5,3	39	27
5,2	53	35
5,2	53	35
5,1	59	3B
5,1	59	3B
5,0	70	46
4,9	75	4B
4,9	75	4B
4,8	82	52
4,8	82	52
4,8	82	52
4,7	95	5F
4,7	95	5F
4,7	95	5F
4,5	106	6A
4,4	110	6E
4,3	113	71
4,2	114	72
4,1	117	75
4,0	117	75
3,8	117	75
3,6	117	75
3,5	117	75
3,3	117	75
3,1	117	75
3,0	117	75
2,8	117	75
2,6	117	75
2,5	117	75

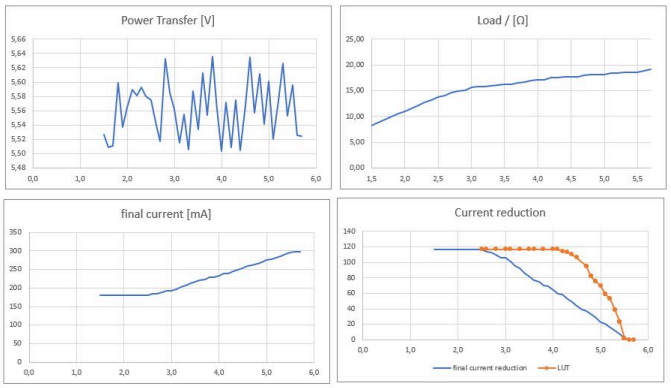

Figure 13. Corrected DPC measurement result

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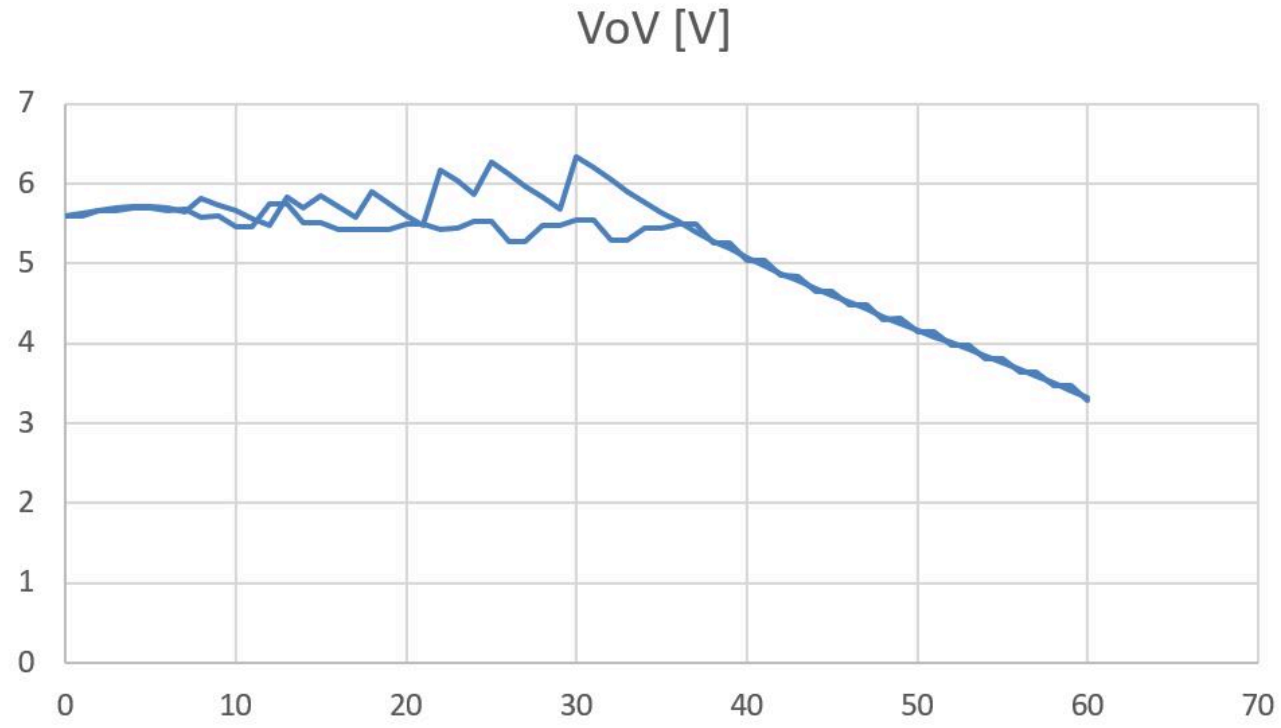

Figure 14. Calibration result example (x = distance in mm, y = VoV in V)

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5 Abbreviations

Table 1. Abbreviations

Acronym	Description
DPC	dynamic power control
LUT	lookup table
NFC	near-field communication
PICC	proximity chip card or NFC smartphone
TX	transmitter
VDDPA	supply voltage of the PN5190 TX driver, as normally controlled by the DPC

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6 References

[1] Data sheet – PN5190B1 NFC frontend (link)
[2] Data sheet – PN5190B2 NFC frontend (link)
[3] Web page – PN5190 – NFC Frontend supporting challenging RF environment for payment, physical access control (link)
[4] Software – NFC Cockpit Configuration Tool for NFC ICs (link)
[5] Application note – AN12549 – PN5190 antenna design guide (link)
[6] Resources – OT6824 – NFC Reader antenna design tools (link)
[7] Resources – NFC Cockpit VCOM source code for PN5190 (link)

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8 Revision history

Table 2. Revision history

Document ID	Release date	Description
UM11899 v.1.0	06 August 2024	• Initial version

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