AN13938

PN7220 – Analog and RF settings

Rev. 2.0 — 29 January 2025 Application note

Document information

Information	Content
Keywords	PN7220, analog settings, RF settings
Abstract	This document describes how to adjust analog and RF settings on the PN7220.

1 Introduction

This document describes how to adjust analog and RF settings on the PN7220.

All settings are stored permanently in EEPROM. The PN7220 is delivered with default settings, which are linked to the FW, for example, the FW update overwrites all related settings.

The settings define the analog and RF behavior. Typically, some adjustment is required to adapt the antenna design and achieve the required performance (transmit power, waveshape behavior, receive sensitivity, loading behavior, current consumption, etc.).

NXP provides the NFC Cockpit to support and simplify this adjustment and handling of settings (refer to [1]). This GUI supports the PN7220.

The derived settings have to be transferred from the XML file into the configuration file structure, which is used in the Android device host (DH). The NFC Cockpit supports the generation of configuration file settings, however, the management of the configuration files must be performed carefully to ensure the intended functionality. For more details, refer to [5].

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2 PN7220 antenna design

The PN7220 uses the same front-end as the PN5190 (refer to [2]). Therefore, the PN5190 antenna design guide ([4]) can be used to design and tune the antenna.

The antenna circuitry is shown in Figure 1.

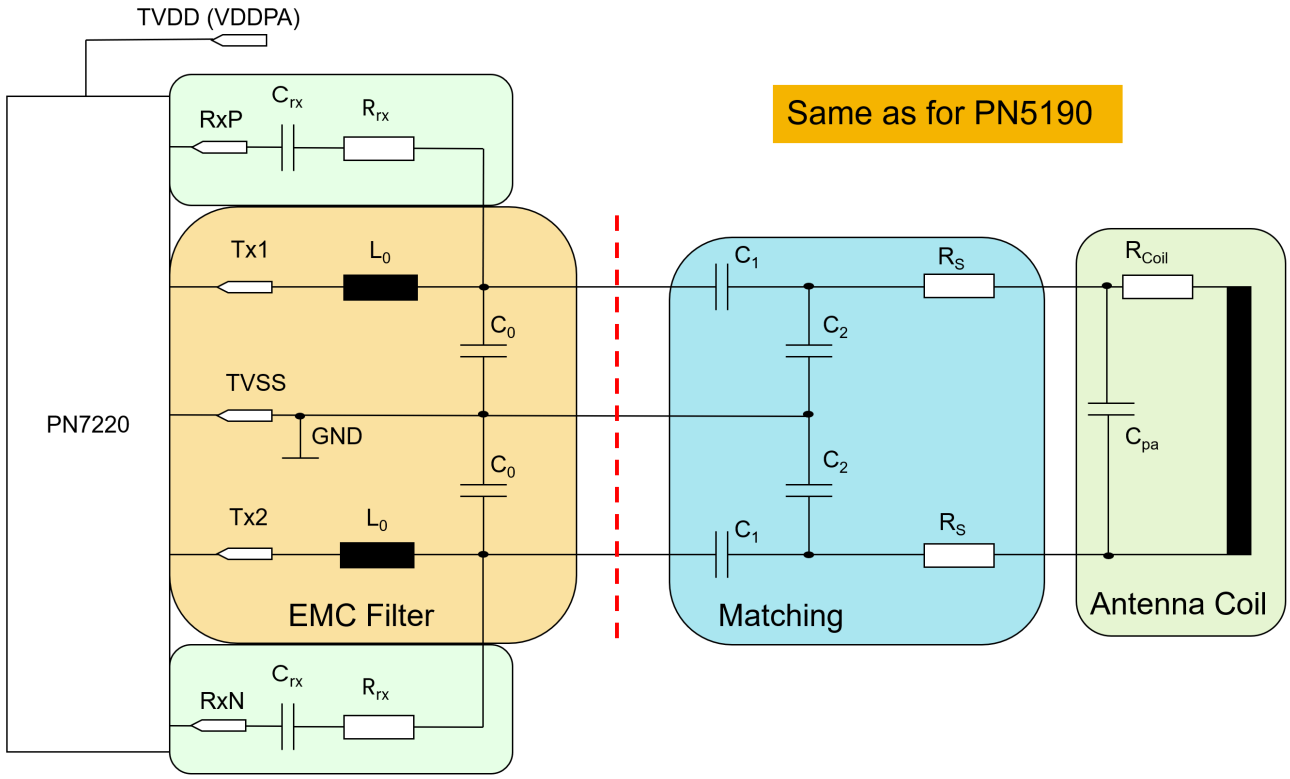

Figure 1. PN7220 tuning circuitry

As a start, the PNEV7220BP1 or PNEV7220BP2 board can be used to connect a customized antenna if needed. The Figure 2 shows the concept, which allows to cut the PCB and reconnect the same or a new antenna with or without an extra tuning circuit via a pin header.

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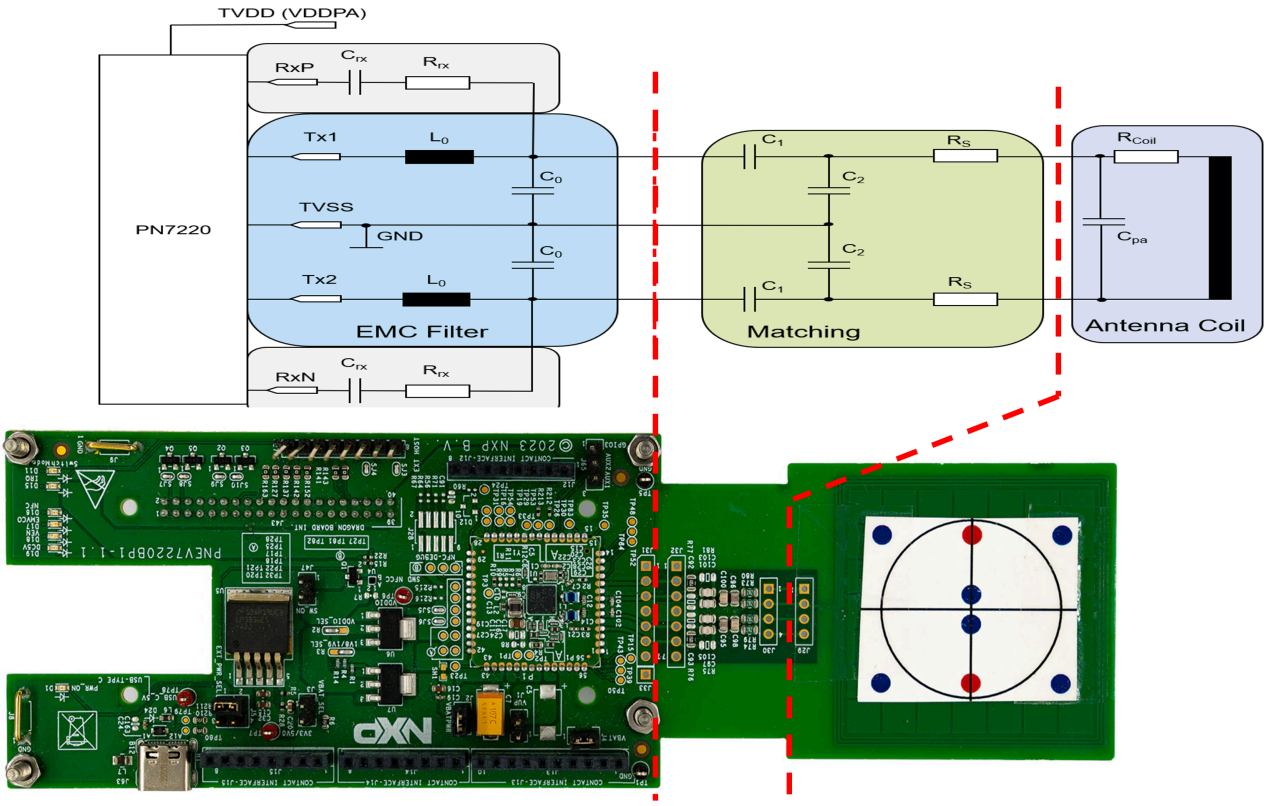

Figure 2. PNEV7220BP1 antenna concept

However, the final antenna design must be tuned in the final hardware setup. The NFC Cockpit allows to test and adjust all the analog and RF settings in the final hardware.

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3 PN7220 settings concept

The PN7220 operates in two different modes:

- NFC mode
- EMVCo mode

Both modes use their own set of settings to allow different configurations between NFC and EMVCo operation. However, only the relevant antenna and DPC related settings are duplicated. The principle is shown in Figure 3.

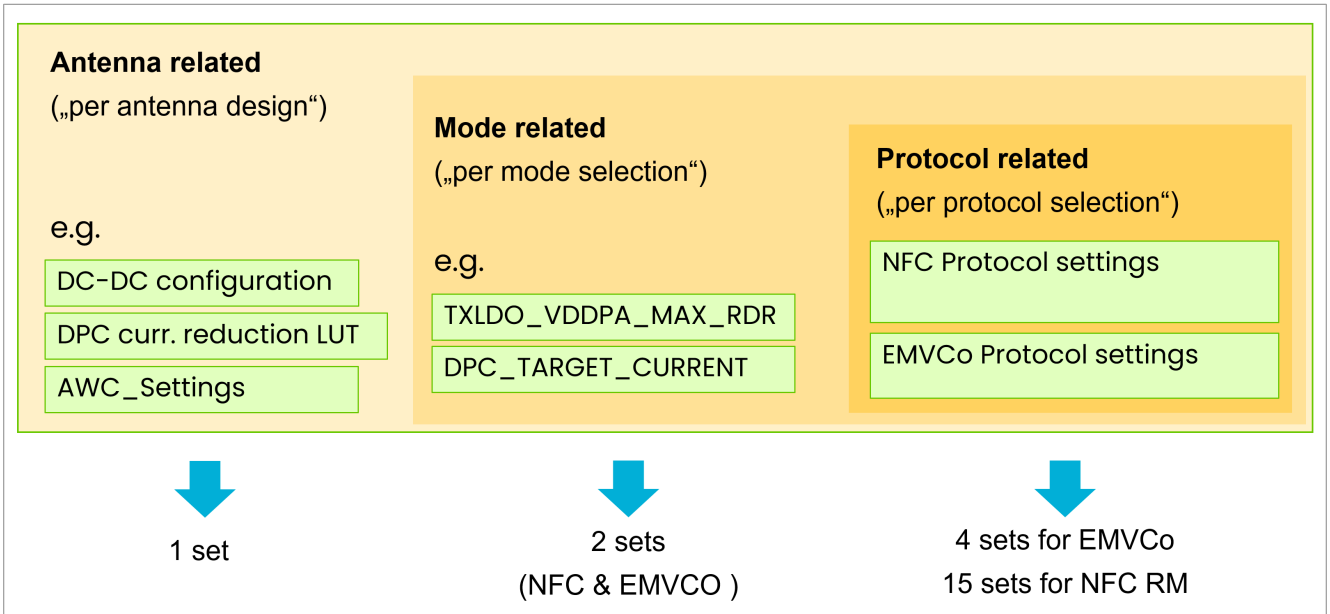

Figure 3. PN7220 settings concept

In principle the settings can be separated into 3 different levels:

1. **Antenna-related settings**: These settings are the same for both modes and commonly used in EMVCo and NFC mode. These settings are antenna-related and contain, for example, the DPC current reduction LUT entries.
2. **Mode-related settings**: These settings are different for both modes and stored separately for EMVCo and NFC operation. These settings are mode-related and contain, for example, the power level definitions. They are applied automatically when the mode is switched.
3. **Protocol-related settings**: These settings can be different for every protocol to address the different type of codings and the data handling for the different technologies. Technologies, which are being used in both modes (for example "Type A106") still have their own set of settings, which allows a slightly different handling between NFC and EMVCo.

3.1 Antenna-related settings

The antennarelated settings are available once in the EEPROM area. They are commonly used and applied in both modes. The most relevant ones are:

1. **DC-DC configuration**: The usage and configuration of the DC-DC is related to the overall hardware design and cannot change with the mode switch.
2. The complete **DPC current reduction lookup table** (LUT) excluding the target current: The DPC current reduction LUT values are related to the antenna loading behavior. The values can be set once per antenna. The power level settings can differ between EMVCo and NFC mode, and are therefore excluded here.

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3. **AWC LUT**: In combination with the loading, some AWC settings might be used to adjust the waveshaping. These AWC settings are commonly applied for both modes.

3.2 Mode-related settings

The mode-related settings are available twice in the EEPROM area. They are separately used in each mode. The most relevant ones are:

1. DPC_Target_Current (TargetCurrent)
2. The maximum allowed VDDPA (TxLdoVddpaMaxRdr)

With these two values, the overall power level can be adjusted differently between NFC and EMVCo mode. The settings can be found in the XML file (for example,*c:\nxp\NxpNfcCockpit_v8.x.x.0\cfg\PN722X\Default \EEPROM_Settings_FactoryDefault.xml*).

NFC-related settings:

```
...
        <Parameter Name="TxLdoVddpaMaxRdr" Offset="0x07" Value="0x2A" />
...
   <Region RegionName="DPC_SETTINGS" RegionAccess="RW" RegionType="DATA">
        <Parameter Name="Config" Offset="0x68" Value="0x77" />
        <Parameter Name="TargetCurrent" Offset="0x69" Value="0x011E" />
        <Parameter Name="Hysteresis_Loading" Offset="0x6B" Value="0x14" />
        <Parameter Name="Hysteresis_Unloading" Offset="0x6E" Value="0x0A" />
        <Parameter Name="TXLDOVDDPALow" Offset="0x6F" Value="0x07" />
        <Parameter Name="TXGSN" Offset="0x70" Value="0x03" />
        <Parameter Name="RDOn_Control" Offset="0x71" Value="0x01" />
        <Parameter Name="InitialRDOn_RFOn" Offset="0x72" Value="0x03" />
        <Parameter Name="TxldoMaxDropOutCfg" Offset="0x73" Value="0x0E10" />
        <Parameter Name="GuardTimeBeforeTx" Offset="0x79" Value="0xFF" />
        <Parameter Name="EnableDPCDuringFDT" Offset="0x7A" Value="0x01" />
        <Parameter Name="GuardTimeAfterRx" Offset="0x7B" Value="0x01" />
```

EMVCo-related settings:

```
...
    <Region RegionName="DPC_SETTINGS_EMVCO" RegionAccess="RW" RegionType="DATA">
        <Parameter Name="Config" Offset="0x68E" Value="0x77" />
        <Parameter Name="TargetCurrent" Offset="0x68F" Value="0x0132" />
        <Parameter Name="Hysteresis_Loading" Offset="0x691" Value="0x14" />
        <Parameter Name="Hysteresis_Unloading" Offset="0x694" Value="0x0A" />
        <Parameter Name="TXLDOVDDPALow" Offset="0x695" Value="0x07" />
        <Parameter Name="TXGSN" Offset="0x696" Value="0x03" />
        <Parameter Name="RDOn_Control" Offset="0x697" Value="0x01" />
        <Parameter Name="InitialRDOn_RFOn" Offset="0x698" Value="0x03" />
        <Parameter Name="TxldoMaxDropOutCfg" Offset="0x699" Value="0x0E10" />
        <Parameter Name="GuardTimeBeforeTx" Offset="0x69F" Value="0xFF" />
        <Parameter Name="EnableDPCDuringFDT" Offset="0x6A0" Value="0x01" />
        <Parameter Name="GuardTimeAfterRx" Offset="0x6A1" Value="0x01" />
    </Region>
...
    <Region RegionName="USER_PMU_EMVCO" RegionAccess="RW" RegionType="DATA">
        <Parameter Name="TxLdoVddpaMaxRdr" Offset="0x6A6" Value="0x2A" />
    </Region>
```


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Note: *The EMVCo-related settings can be read and written with the NFC Cockpit, but can not be applied and used. The PN7220 test mode, which is used to support the NFC Cockpit, does not support the usage of EMVCo-related settings.*

3.3 Protocol-related settings

Both modes use protocol settings, which are automatically applied before enabling the RF field or when switching the technology during the polling sequence. These protocol settings are stored and handled for each protocol.

NFC TX-protocols:

1. A106, A212, A424, A848
2. B106, B212, B424, B848
3. F212, F424
4. 15693 10%ASK, 15693 100%ASK
5. PICC 106, PICC 212, PICC424, PICC 848

NFC RX-protocols:

1. A106, A212, A424, A848
2. B106, B212, B424, B848
3. F212, F424
4. 15693 6P6, 15693 26, 15693 53, 15693 106, 15693 212
5. PICC 106, PICC 212, PICC424, PICC 848

EMVCo TX-protocols:

1. A106
2. B106
3. F212, F424

EMVCo RX-protocols:

1. A106
2. B106
3. F212, F424

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4 Preparation

Some preparation must be performed to allow adjustment and storage of the correct settings in the PN7220.

4.1 How to run the NFC Cockpit

The NFC Cockpit installation includes an Android server application, which allows to connect the PN7220 to the NFC Cockpit. To install (copy) the application and start it properly, by simply running the related batch file from *c:\nxp\NxpNfcCockpit_v8.1.x.x\firmware\Secondary_Pn722x\Android*. This batch file disables the NFC polling and starts the server application, as shown in Figure 4.

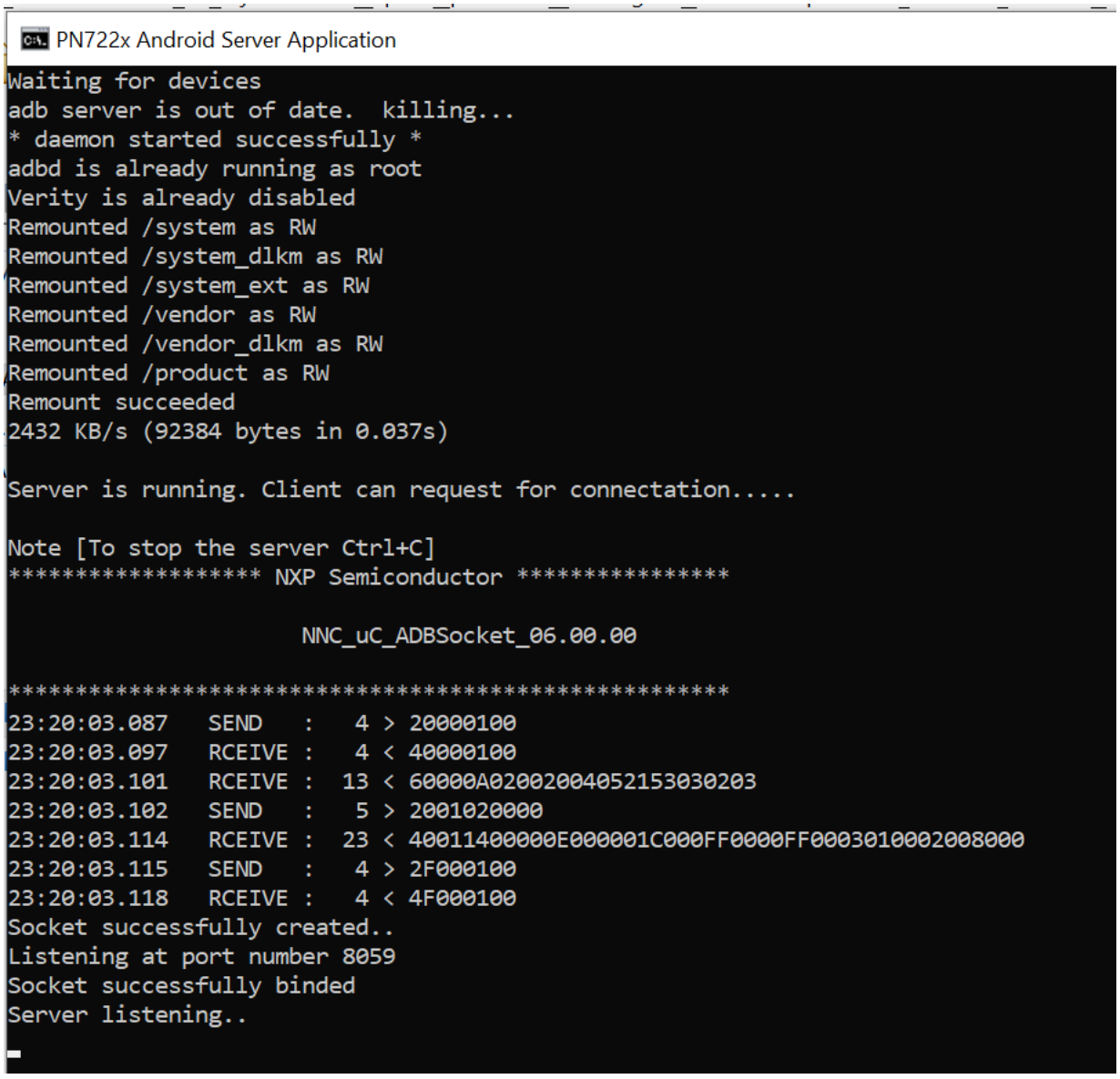

Figure 4. Example: Start of Android Server Application

Now, the NFC Cockpit can be started.

Note: *It might be required to unlock the Android screen to enable the NFC, before the batch file can start the server application.*

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4.2 NFC Cockpit limitations

The current version 8.1.2 of the NFC Cockpit in combination with the PN7220 firmware version 3.2.3 has some known limitations. The major limitation is related to the usage of EMVCo-related settings: The EMVCo-related setting can be managed with the NFC Cockpit, for example, they can be read and written, but cannot be applied and used in the NFC Cockpit.

This requires a manual copying of settings, either using the NFC Cockpit or directly copying the settings inside the XML file. However, a final test with the EMVCo functions like the loopback function requires an EMVCo test application anyway.

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5 Adjustment of settings

As previously mentioned, the PN7220 FW comes with default settings. These default settings *normally* protect the PN7220 and avoid damage. Typically, these default settings do not guarantee the optimum operation with any antenna other than the 45mm x 45mm antenna of the PNEV7220BP1 or PNEV7220BP2.

The overall hardware configuration has a major impact on the settings. The PN7220 offers a flexible power configuration with and without DCDC as well as with and without DPC, and two different antenna configurations: balanced and unbalanced ("single-ended"). The default settings provide a proper operation and no damage, if the DCDC and a balanced antenna are used. **Otherwise, the EEPROM settings MUST be changed before the RF is enabled the first time!**

5.1 Required settings before RF on

The PN7220 can be used in different power configurations, as listed in [6]. The default configuration uses the DCDC including the DPC: this configuration is covered within the default settings. These default settings provide a basic operation and no damage, if the DCDC and a balanced antenna are used.

As soon as no DCDC and/or a single-ended antenna are used, some settings must be changed, before the RF is enabled for the first time to avoid damage.

5.1.1 Power settings

The PN7220 can be used in different power configurations, as listed in [6]. The **default configuration** uses the DCDC as well as the DPC: this configuration is covered within the default settings. Some parameters like minimum and maximum VDDPA, maximum current and the related DPC behavior should be adjusted for the optimum operation, but enabling the RF with default settings does not damage the PN7220.

If the hardware does not use the DCDC, but supplies VUP differently, the DCDC must be disabled, i.e the **DCDC_PWR_CONFIG (0x0000)** must be configured to "DC-DC is not powered and set to bypass". The related VUP input voltage must be set accordingly. This must be done before the first time RF is enabled to avoid damage.

5.1.2 Antenna settings

The PN7220 can be used in two different antenna configurations, as listed in [6].

The default configuration uses a balanced antenna, so the TX1 and TX2 operate in opposite phase. As soon as the single ended antenna configuration is used, and TX1 and TX2 are connected to each other, the settings must guarantee the operation of TX1 and TX2 in phase, otherwise the PN7220 will be damaged. The related settings are listed in the datasheet, and must be set, before the RF is enabled.

5.2 Performance optimization

The first step for the analog optimization is the DPC calibration. This can be done with the NFC Cockpit and with the help of [3].

Be aware that the DPC calibration as such is the same for both, the NFC mode as well as the EMVCo mode. So the DPC calibration shall be done for the operation, which requires the higher field strength, which is normally EMVCo. The mode related settings like the maximum VDDPA and / or the target current can be used to reduce the power for any mode. With the DPR, the power can even be changed differently at any time later during operation.

Make sure that the RX is connected properly, i.e. the HFAtt value is correct (refer to [7]). Then it makes sense to check the overall noise behavior and measure the SDT with the CTS multi-capture function of the NFC Cockpit. As long as the used settings of the DGRM_SIGNAL_DETECT_TH_ OVR_VAL in the CLIF_DGRM_RSSI

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(0x30) register is lower than the SDT (using a margin of 6), there is risk that noise detection disturbs the NFC or EMVCo operation.

The CTS can be used to analyze system noise.

Note: *The DGRM_SIGNAL_DETECT_TH_ OVR_VAL is automatically set by the PN7220 FW: either it is defined in the protocol settings and copied into the CLIF_DGRM_RSSI (0x30) register with the "Load Protocol", or it is defined in the ARC settings, and then automatically set by the DPC. The DGRM_SIGNAL_DETECT_TH_ OVR_VAL needs to be set in combination with the MFGAIN in the CLIF_SIGPRO_RM_TECH (0x22) register and the IIR filter.*

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6 Save EEPROM settings

To apply new settings stored in a new XML to the PN7220, the NFC Cockpit tool can be used. The NFC Cockpit allows to read and write EEPROM settings in the direct area, as well as it allows to read and write EEPROM from the RF configuration area ("Load Protocol" area) indirectly.

These EEPROM settings are permanently stored and used in all three modes (NFC mode, EMVCo mode or Test mode).

However, the EEPROM management normally is handled by the Android host. So the Android DH can overwrite EEPROM settings (automatically), if configured so. The details can found in [5].

Note: *Make sure that the DH does not overwrite any EEPROM settings, when switching between Test mode and NFC mode operation during the optimization!*

Note: *Make sure that the DH does overwrite the EEPROM settings during normal operation only, if needed (to avoid unneccessary EEPROM writing).*

When all settings are optimized and properly configured, it is recommended to save the complete EEPROM into an XML file, using the NFC Cockpit function <Dump EEPROM>. This file then can be used as reference.

The NFC Cockpit provides the functionality to identify delta settings, for example, those settings which are different from the factory default. The it can be used to turn these delta settings into CONF files, which then can be applied in the Android system to configure every device properly. See [5] for details.

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7 Abbreviations

Table 1. Abbreviations

Acronym	Description
DH	device host
DPC	Dynamic Power Control
DPR	Dynamic Power Reduction
FW	firmware
SDT	Signal Detection Threshold

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8 References

[1] Software – NFC Cockpit (link)
[2] Web page – PN5190 – NFC Frontend supporting challenging RF environment for payment, physical access control (link)
[3] Resources – PN5190 Antenna design tools (link)
[4] Application note – AN12549 – PN5190 antenna design guide (link)
[5] Application note – AN14431 – PN7160/PN7220 configuration files (link)
[6] Data sheet – PN7220 – NFC controller with NCI interface supporting EMV and NFC Forum applications (link)
[7] Application note – AN12551 – PN5190 design-in recommendations (link)

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10 Revision history

Table 2. Revision history

Document ID	Release date	Description
AN13938 v.2.0	29 January 2025	Updated for the usage with regular NFC Cockpit. Editorial changes. • Section 1 "Introduction": updated. • Section 2 "PN7220 antenna design": added. • Section 4 "Preparation": updated. • Section 4.1 "How to run the NFC Cockpit": added. • Section 4.2 "NFC Cockpit limitations": added. • Section 5.1 "Required settings before RF on": added. • Section 6 "Save EEPROM settings": updated. • Section 7 "Abbreviations": updated. • Section 8 "References": updated.
AN13938 v.1.0	7 July 2023	• Initial version.

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