Basic Tests of NFC Enabled Devices Using R&S Test Equipment

Application Note

Products:

- R&S®SMBV100A
- R&S®SMBV-K89
- R&S®FS-FS-K112PC
- R&S®RTO
- R&S®RTO-K11
- R&S®CSNFC-B8
- R&S®FSL
- R&S®FSV
- R&S®FSW
- R&S®ZVL

This application note describes how to perform basic NFC analog tests of NFC-enabled devices and NFC tags. The tests are carried out with R&S test instruments and R&S NFC Measurement Software, using the NFC Forum Reference devices available from R&S.

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1 Abstract

This application note explains how to carry out basic tests as defined by the NFC Forum Analog Specification, of NFC-enabled devices in listening and polling mode. NFC Tags which support only listening mode are tested the same way.

Test antennas, the NFC Forum Reference Devices, are required to carry out the tests. R&S offers antennas R&S®CSNFC-B8 which are compliant to the NFC Analog specification. For NFC signal generation an SMBV with option Digital Standard NFC-A/B/F SMBV-K89 is used. Poller signals are available at the RF output of the SMBV, listener signals are available at the baseband I-output on the rear side of the generator.

The NFC Measurement Software FS-K112PC controls an RTO oscilloscope with RTO-K11 (or alternatively an R&S Signal or Spectrum Analyzer) which captures the NFC signals and delivers I/Q data to the FS-K112PC. The FS-K112PC analyses the signal and delivers pass/fail information for both poller and listener signals. Where this application note refers to an RTO a suitable analyzer FSV, FSW, FSL or ZVL could also be used.

The NFC Measurement Software FS-K112PC can be controlled remotely and thus all its functions can be integrated in a customer's test software.

Note: For some more advanced tests (which are not described in the following e.g. testing Modulation Sensitivity in polling mode) a specific NFC Trigger is necessary which is provided by the RTO but not with R&S signal- and spectrum analyzers).

The following abbreviations are used in this application note for R&S® test equipment:

The R&S®RTO is referred to as the RTO.

The R&S®SMBV100A is referred to as the SMBV.

The R&S®FSW is referred to as the FSW.

The R&S®FSV is referred to as the FSV.

The R&S®FSL is referred to as the FSL.

The R&S®ZVL is referred to as the ZVL.

The R&S®FS-K112PC is referred to as the FS-K112PC.

2 Test Setup

2.1 NFC Reference Devices

2.1.1 Reference Polling Devices

When connected to the RF output of a suitable signal generator like the SMBV100A via connector J1, an NFC Forum Reference Polling Device sends commands to a listening device. The response from a listening device can then be captured and analyzed by measurement equipment, for example an RTO connected to the J2 connector, controlled by the NFC Measurement Software FS-K112PC.

NFC Forum Reference Polling Devices with 3 different antenna coil designs are defined (poller 0, poller 3 and poller 6) and are part of the “NFC Forum Reference Equipment” R&S®CSNFC-B8.

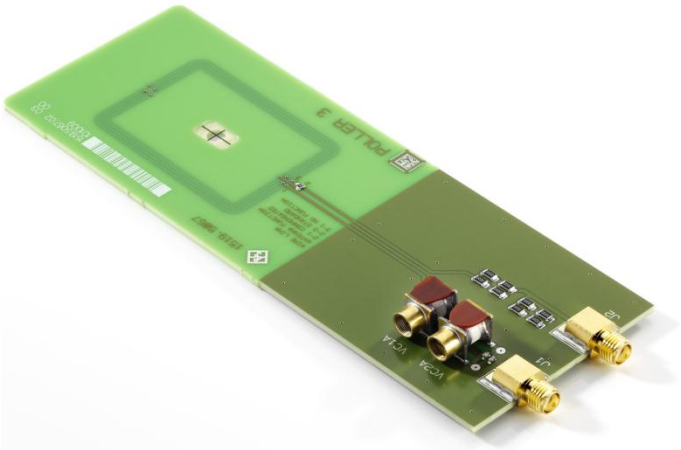


Fig. 2-1:: NFC Forum reference poller 3 (part of R&S®CSNFC-B8)

2.1.2 Reference Listening Devices

A NFC Forum reference listening device is used to capture the signal transmitted by a polling device. For analyzing the frequency and wave-shapes of captured signals, the NFC Forum reference listening device is equipped with an integrated sense coil, the received signal is available at the sense coil output connector J4 which has to be connected to the RTO controlled by the NFC Analysis Software FS-K112PC.

The NFC Forum reference listening device can also send information back to a polling device, using various levels of load modulation generated by the SMBV baseband I-output on the rearside.

The power transferred by the polling device under test is measured via the VDC out connector J1 where the rectified induced voltage of the listener coil is output. The RTO

(channel 2, DC coupling, 1 MOhm) has to be connected via a probe RT-ZP10 and an adapter like the R&S®RT-ZA10 to this connector.

The VDC output voltage measurement is not supported by FS-K112PC but can easily be done by the RTO directly.

NFC Forum Reference Listening Devices with 3 different antenna coil designs are defined (listener 1, listener 3 and listener 6) and are part of the R&S®CSNFC-B8.

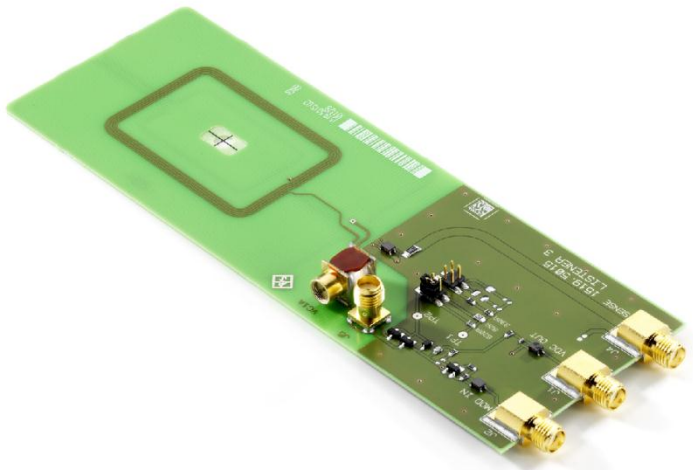


Fig. 2-2: NFC Reference Listener 3 (part of R&S®CSNFC-B8)

2.2 Operating volume – geometric test points

NFC analog tests have to be carried out on certain test points (14 points in total) within the so-called operating volume which is a trunctated pyramid like shown in Fig. 2-3

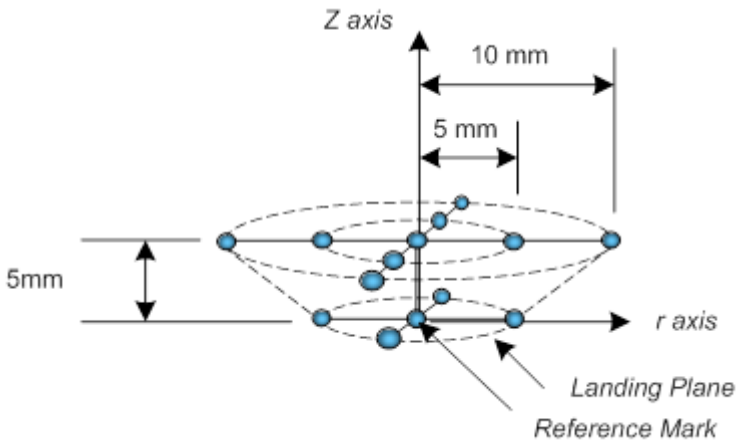


Fig. 2-3: Operating volume as defined by the NFC Forum Analog Specification

Ideally the Reference Mark should be marked on the rearside of an NFC enabled device but often is not marked up to now (in this case try to find a point where the power transfer is optimum, see chapter 3.2 for power transfer measurement).

The test points are defined by 3 coordinates z, r, φ like shown in Fig. 2-4 whereas z can be 0 (vertical distance from Reference Mark = 0 mm) or 1 (vertical distance from Reference Mark = 5 mm).

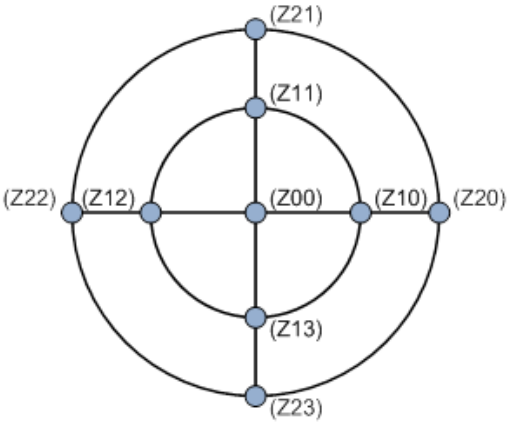


Fig. 2-4: Target test points and coordinates (z, x, y)

The R&S NFC Reference antennas have a cross mark centered on the geometrical center of the antenna so the devices can be easily aligned to a Reference Mark of a NFC enabled device. The orientation of the R&S NFC Reference antennas versus the NFC enabled devices is shown in Fig. 2-5 (The component side of the Reference antennas is opposite to the NFC Enabled device under test).

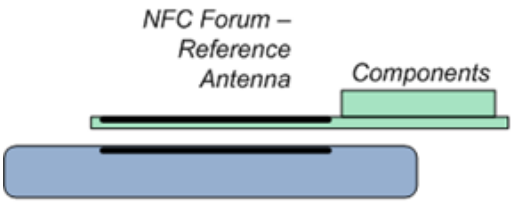


Fig. 2-5: Orientation of NFC Forum Reference Equipment

Within the NFC Analog Specification there is a setup configuration defined, mainly to adjust the RF level input to connector J2 of the NFC Reference Pollers as a function of the position (z, r, φ = 1,0,0 which means centered position with 5 mm distance) and the DC voltage measured at connector J1 (VDC OUT) of the according reference listeners. Fig. 2-6 shows the relative orientation of the NFC Reference antennas during setup.

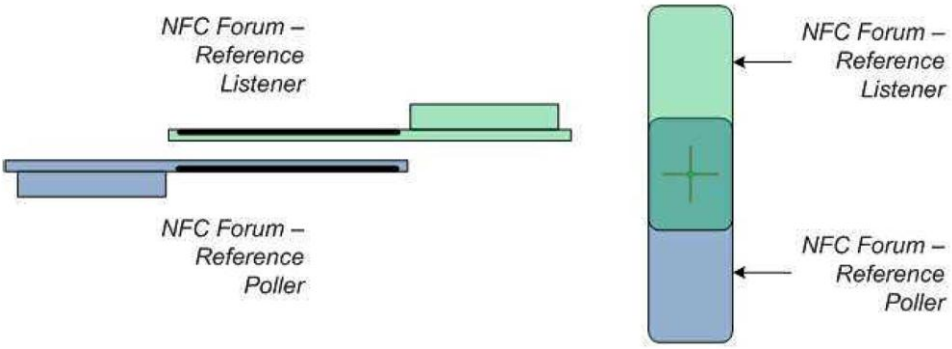


Fig. 2-6: Relative orientation of NFC Forum Reference Equipment during set-up (left: side view, right: top view)

2.3 Test Setup for Tests on NFC-enabled Devices in Listening Mode or for NFC Tags

The test setup for tests on NFC-enabled devices in Listening Mode or for NFC Tags is shown below. One of the NFC Reference Pollers (part the R&S®CSNFC-B8) is used to couple to the NFC enabled device under test and to connect the instruments. An SMBV with option SMBV-K89 NFC-A/B/F Digital Standard generates the necessary polling Signal. An RTO with option IQ-software interface RTO-K11 (or as an alternative a signal analyzer in IQ mode) controlled by the NFC Measurement Software FS-K112PC records the sense signal. FS-K112PC analyses in-depth the recorded IQ-data including pass/fail information and command decoding.

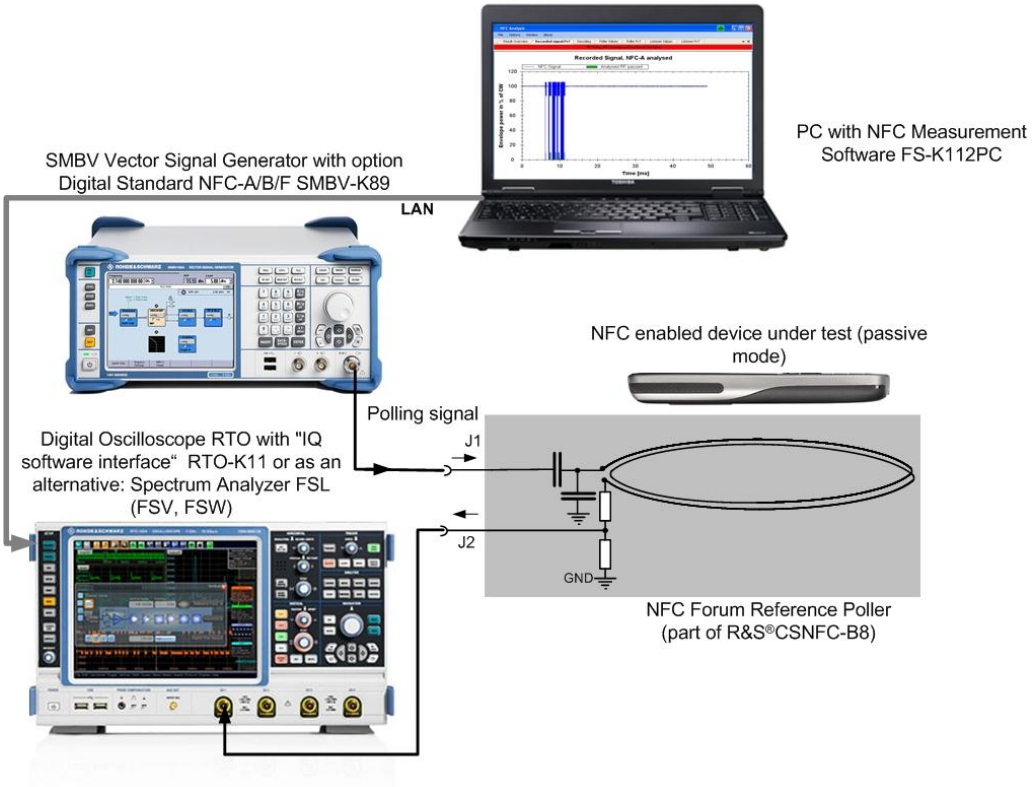


Fig. 2-7:Test setup for tests of NFC-enabled devices in listening mode or NFC tags

2.4 Test Setup for Tests on NFC-enabled Devices in Polling Mode

The test setup for simple tests on NFC-enabled devices in polling mode is shown below. One of the NFC Reference Listeners (part the R&S®CSNFC-B8) is used to couple to the NFC enabled device under test and to connect the instruments.

The sense output is connected to channel 1 of an RTO (or as an alternative to the RF input of a signal analyzer). The VDC output is connected via a 10:1 probe, like the RT-TP10, to channel 2 of the RTO scope (set coupling for channel 2 to DC, 1MOhm). If a signal analyzer instead of an RTO is used to record the IQ data, use any other oscilloscope. For basic tests in polling mode, the “Mod In” input of the reference listener is not used.

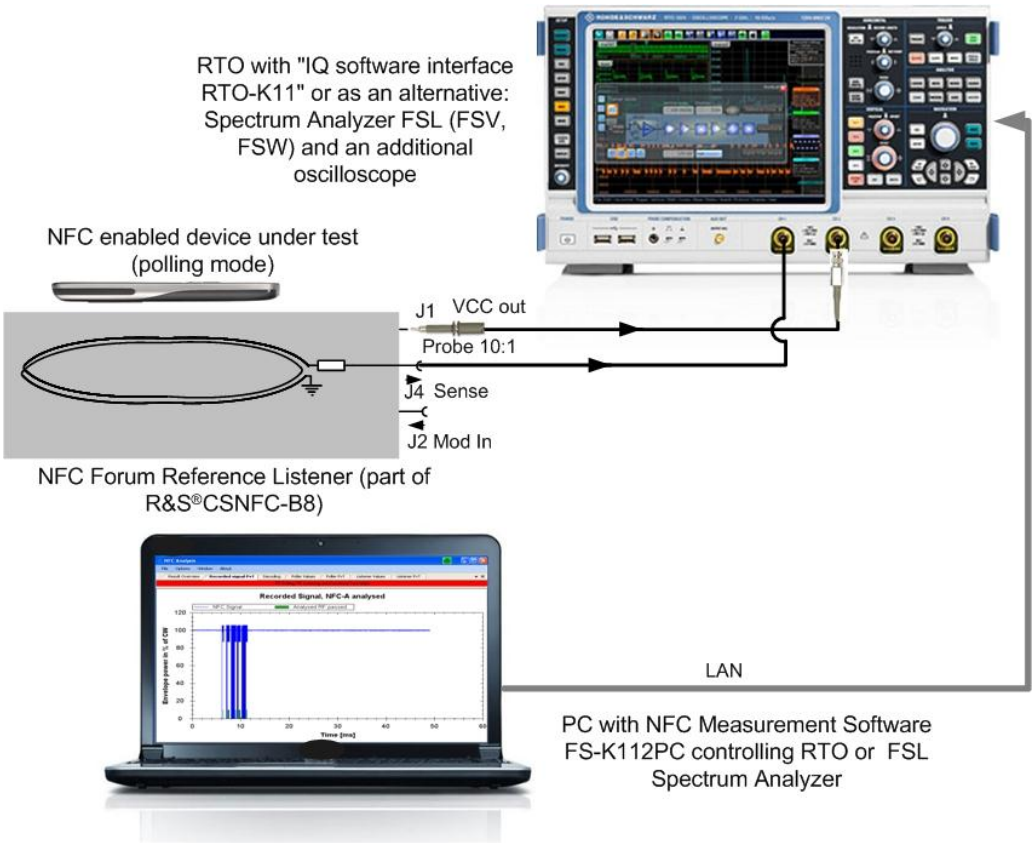


Fig. 2-8:Test Setup for simple polling tests on NFC-enabled devices. Instead of an RTO a spectrum analyzer controlled by the NFC Measurement Software FS-K112PC could be used plus an additional simple oscilloscope.

3 Basic polling tests

3.1 Setting up the Test

Connect a reference listener (e.g. listener 3) as shown in Fig. 2-8 and place the device under test (e.g. a mobile phone) with its back on the NFC Forum Reference Listener as shown below.

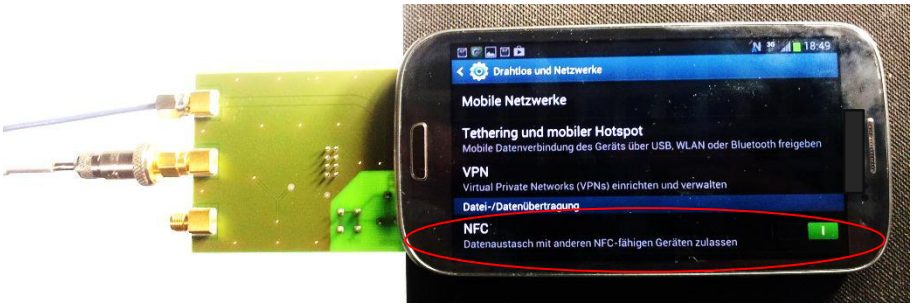


Fig. 3-1: Putting the NFC enabled phone on the Reference Listener for testing poller function (it is recommended to use the solder side of the Reference Listener). NFC has to be switched on in the phone settings.

Some tips for setting up the phone:

- Switch NFC on

- Set screen timeout to maximum because for most NFC devices the NFC polling is switched off in parallel with the screensaver

3.2 Power Transfer and Carrier Frequency Test - Done with basic RTO functions

Power Transfer and Carrier Frequency test on an NFC enabled device are not supported by the FS-K112PC NFC Measurement Software but can be done easily using the RTO basic functions.

Power Transfer is tested by measuring the DC voltage via a probe at J1 (VDC during the un-modulated part of the poller signal).

Carrier Frequency is tested using the Sense output (J4) again during the un-modulated part of the poller signal

Steps for setting up the RTO:

1. Preset
2. Horizontal: Time Scale 200us/div
3. Channel 1: DC 50 Ohm

4. Adjust vertical scale so that signal is within scale
5. Trigger: NFC (NFCA)
6. Adjust trigger level to about 50% of max. positive amplitude
7. Trigger Mode: Normal
8. Open 2nd window at RTO screen
9. Channel 2: DC 1MOhm (default setting)
10. Adjust vertical scale so that DC is within scale
11. Draw *Measurement 1* window at upper diagram and setup *Frequency* measurement
12. Draw *Measurement 2* window at lower diagram and setup RMS measurement

Measurement Windows 1 shows the measured carrier frequency during the CW part

Measurement Window 2 shows the RMS value of the DC voltage at J1

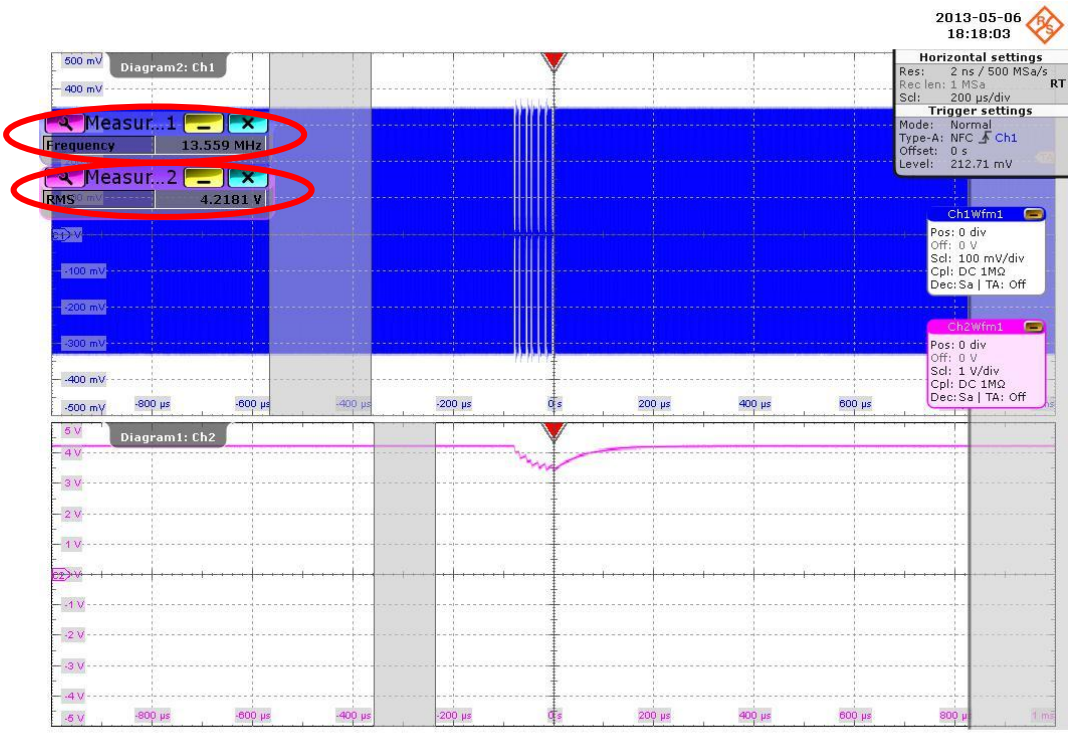


Fig. 3-2: Example of a power transfer measurement (upper trace) on an NFC enabled device in polling mode in parallel with a carrier frequency measurement (lower trace) with the Digital Oscilloscope R&S®RTO. Measurement window 2 shows the DC voltage and measurement window 1 the carrier frequency.

3.3 Tests Using the NFC Measurement Software FS-K112

3.3.1 Setting up the NFC Measurement Software

Start the NFC Measurement software on the PC and set up a LAN connection with the RTO (or signal analyzer). The connection can be tested in FS-K112PC under “Settings” with the *Check Connection* button.

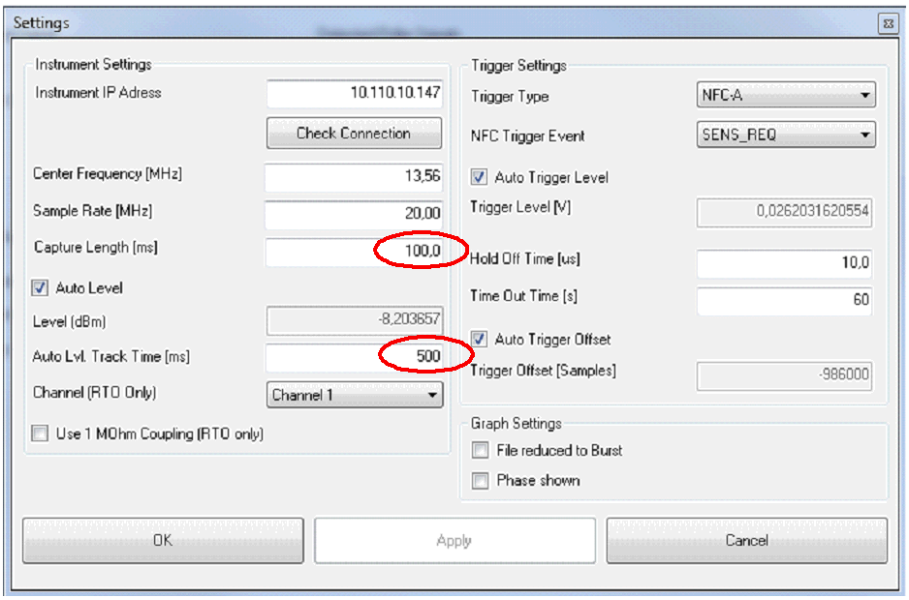


Fig. 3-3:The Settings window for the NFC Measurement software FS-K112PC. “Trigger Type” is set to “NFC-A” by default and “Trigger Event” to “SENS_REQ” (with an signal analyzer use “Trigger Type” “IF Power”) Change “Capture Length” to “100 ms” and “Auto Level Track Time” to at least “300 ms”.

Trigger Type is set to *NFC-A* by default and *Trigger Event* to *SENS_REQ* (with an signal analyzer use *Trigger Type IF Power*, there is no specific NFC trigger available).

Change the parameter *Auto Lvl Track Time* to at least about *300 ms* within *Tools-Settings* in FS-K112PC to be sure that the auto ranging of the scope finds the correct range and trigger level. For some NFC enabled phones an even longer *Lvl Track Time* may be needed dependent on the pauses of the polling.

Setup the *Capture Length* to about *100 ms* to capture all different polling signals in one trace. Select the used RTO input (normally input 1) connected to the sense output of the reference listener.

3.3.2 Start the NFC Measurement Software

Start the measurement and analyze the captured signal by clicking the ▶ button as shown below.

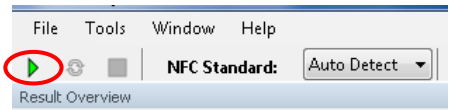


Fig. 3-4:Start measuring with NFC Measurement Software FS-K112PC by clicking the ▶button

A typical result should look like this:

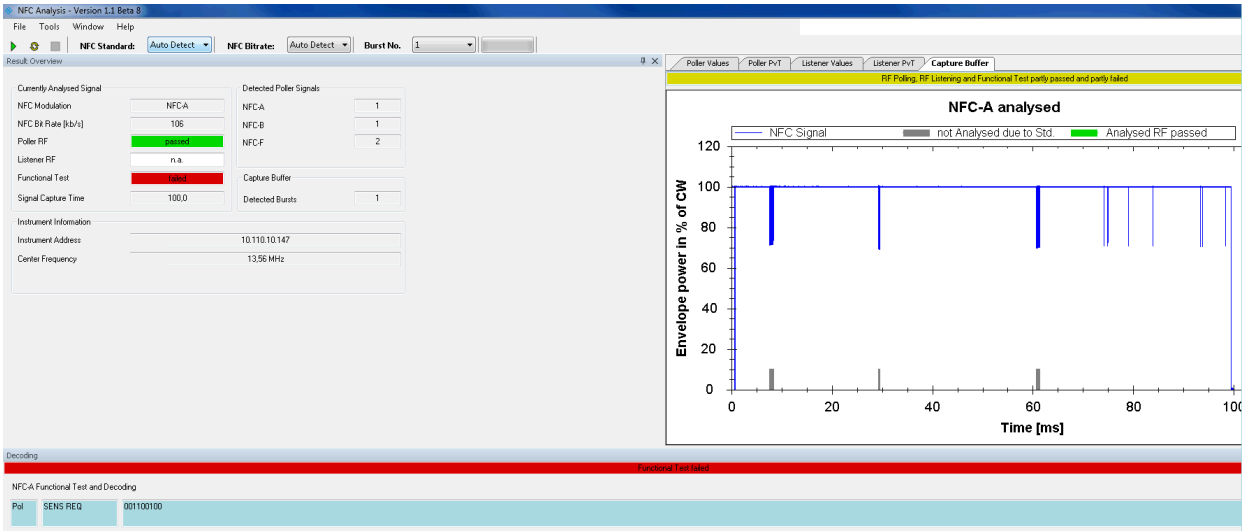


Fig. 3-5: Typical result for the NFC Measurement Software FS-K112PC on a polling NFC device. The result overview is shown on left side. An NFC-A signal was detected and analyzed and an NFC-B and two NFC-F signals were detected. The capture buffer display on right side shows the leading NFC-A signal and 3 further NFC Signals, followed by some spikes.

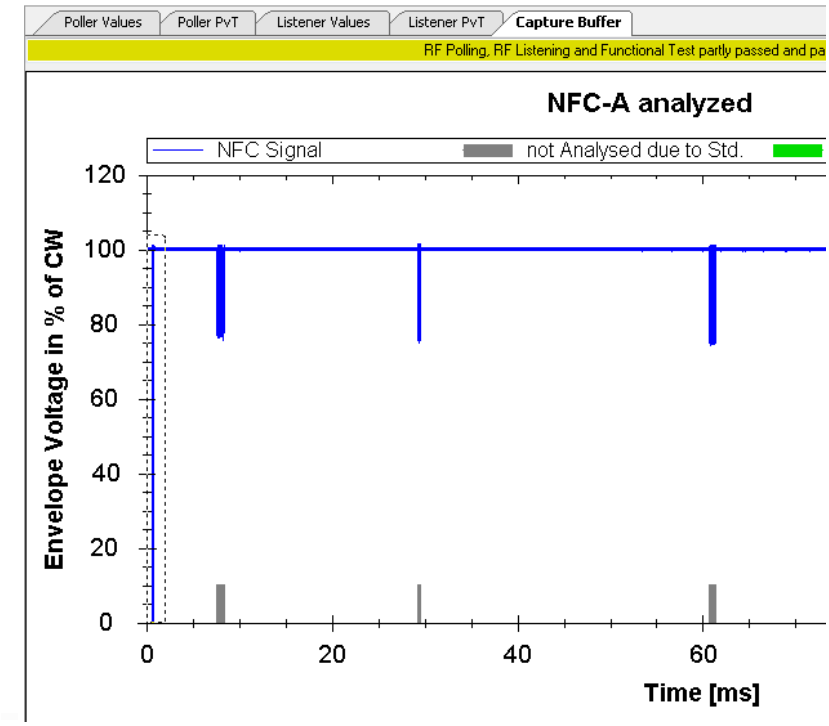


Fig. 3-6: Zoom to a certain section of the Capture buffer display using the left mouse key to see, for example, the leading NFC-A poller signal in detail.

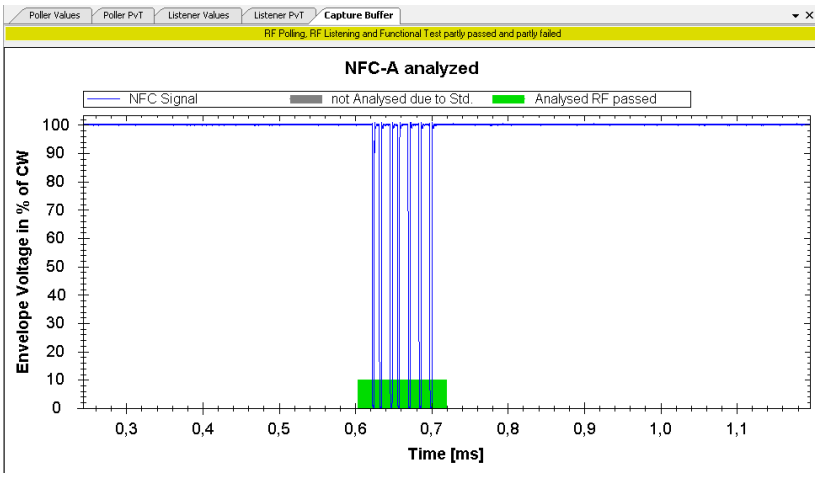
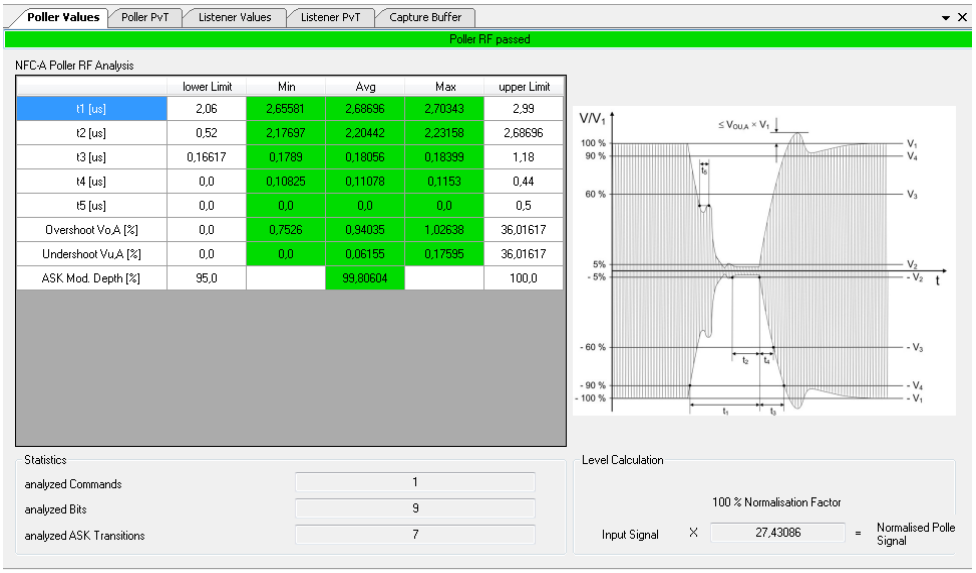


Fig. 3-7: Zoomed part of the Capture Buffer display

Instead of the *Capture Buffer* display you can choose the *Poller Values* display which shows the timing parameters of the poller signal whereas *Poller PvT* shows the detailed slopes of the poller signals. No Listener Signal was detected therefore there are no *Listener Values* or *Poller PvT* signals displayed.



	lower Limit	Min	Avg	Max	upper Limit
t1 [us]	2,06	2,65581	2,68696	2,70343	2,99
t2 [us]	0,52	2,17697	2,20442	2,23158	2,68696
t3 [us]	0,16617	0,1789	0,18056	0,18399	1,18
t4 [us]	0,0	0,10825	0,11078	0,1153	0,44
t5 [us]	0,0	0,0	0,0	0,0	0,5
Overshoot Vo,A [%]	0,0	0,7526	0,94035	1,02638	36,01617
Undershoot Vu,A [%]	0,0	0,0	0,06155	0,17595	36,01617
ASK Mod. Depth [%]	95,0		99,80604		100,0

Fig. 3-8: Timing Values of the poller signal are displayed with Poller Values. All pulses of the analyzed poller signal are taken into account to get the minimum, maximum and average timing values.

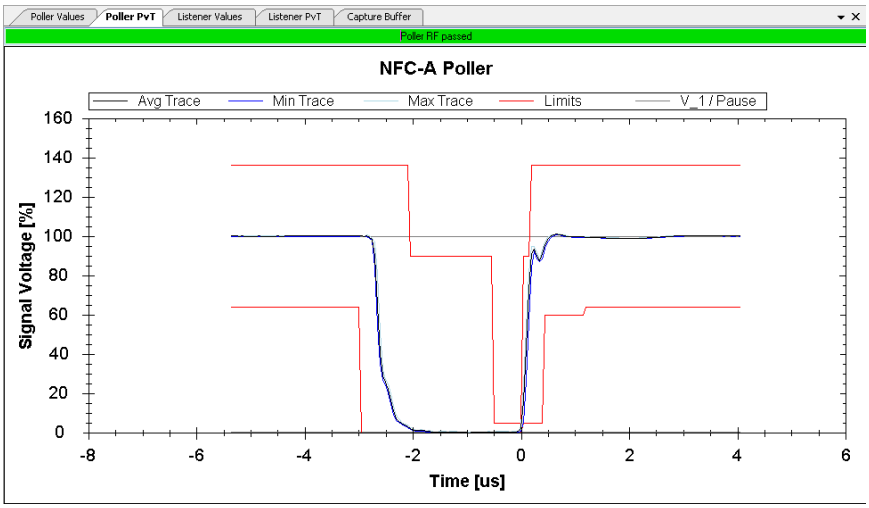


Fig. 3-9: Poller PvT display of the analyzed poller signal. All pulses of the signal are overlaid to average minimum and max traces to show variations between the different pulses

3.3.3 Analyze a captured signal according to a fixed standard (NFC-A, NFC-B or NFC-F)

In *Auto Detect* mode the first NFC signal found in the capture buffer is automatically detected and analyzed. Select a certain standard (e.g. *NFC*-B) to search for such a signal in the capture buffer and analyze it.

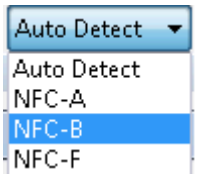


Fig. 3-10: Select "NFC-B" detection to detect and analyze an NFC-B signal within the capture buffer.

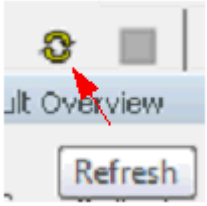


Fig. 3-11: Refresh analyzing the captured signal by clicking on the "Refresh" button.

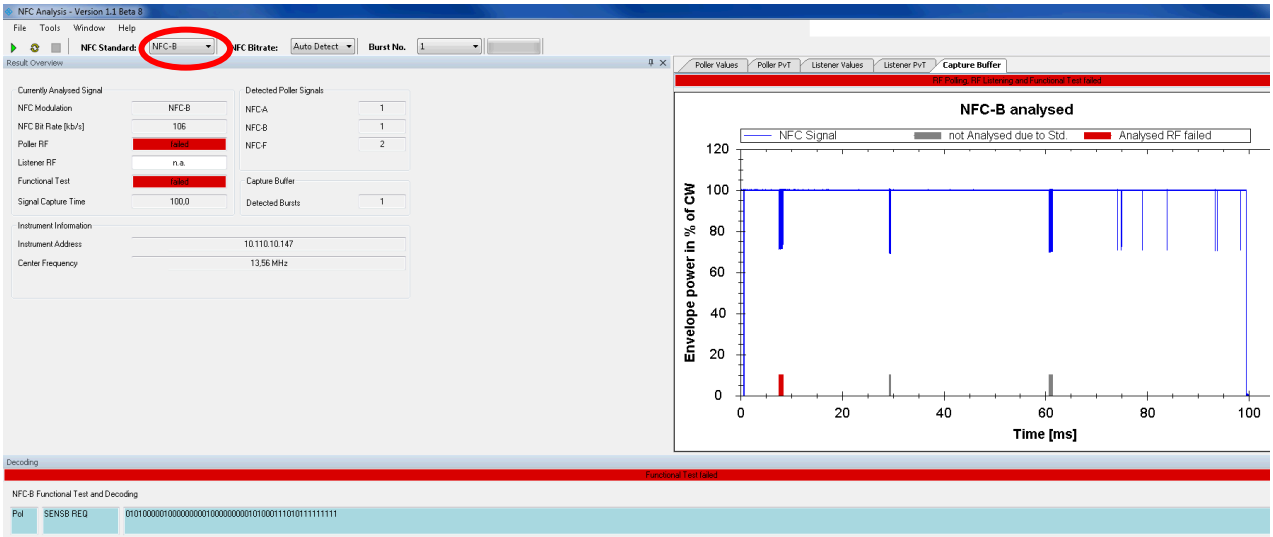


Fig. 3-12: With NFC Standard set to NFC-B the second signal in the capture buffer is detected as an NFC-B SENS_REQ signal and analyzed accordingly.

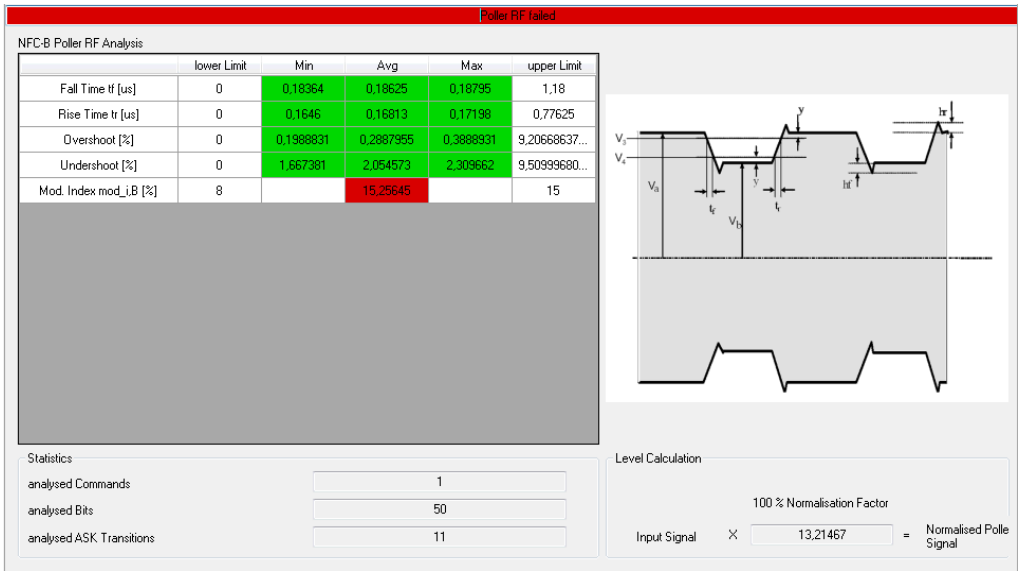


Fig. 3-13: The reason for the fail info is that the modulation index is slightly above the upper limit of 15%.

3.3.4 Selecting a different burst within the capture buffer manually

Depending on the device under test, there may be different polling signals (NFC-A, NFC-B or NFC-F) in different bursts. By default FS-K112PC analyzes only the first burst found. But with the refresh function also the second or third burst can be selected manually to analyze using the *Burst No* function.

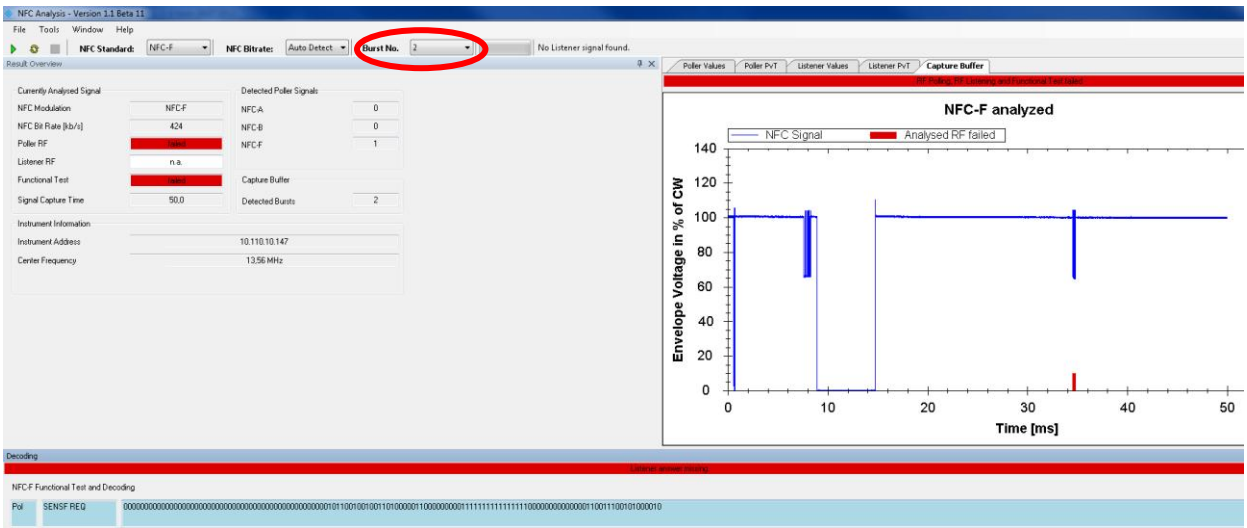


Fig. 3-14: Selecting the second burst within the capture buffer (Burst no. 2) to be analyzed. A SENSF_REQ signal was found and analyzed.

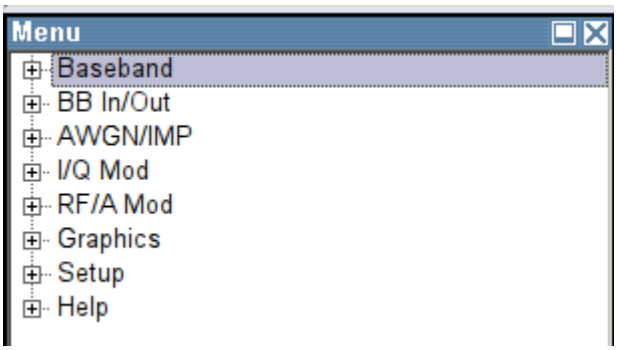
4 Basic listener tests

For a listener test a stimulation poller signal is necessary. This is generated by the vector signal generator SMBV with option Digital Standard NFC SMBV-K89. The test setup shown in chapter 2.3 is used in combination with one of the reference pollers for testing the listening function of an NFC-enabled device or an NFC tag.

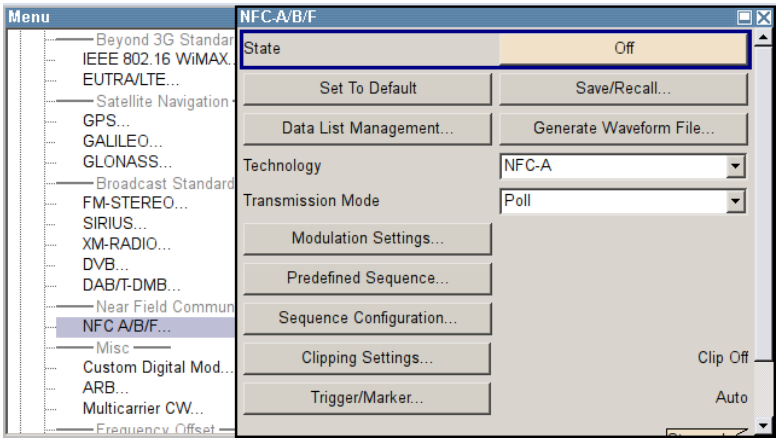
4.1 How to generate polling signals using the SMBV

4.1.1 Setting up an NFC-A polling sequence

1. Press *Menu* Hardkey/*Baseband* at the SMBV:

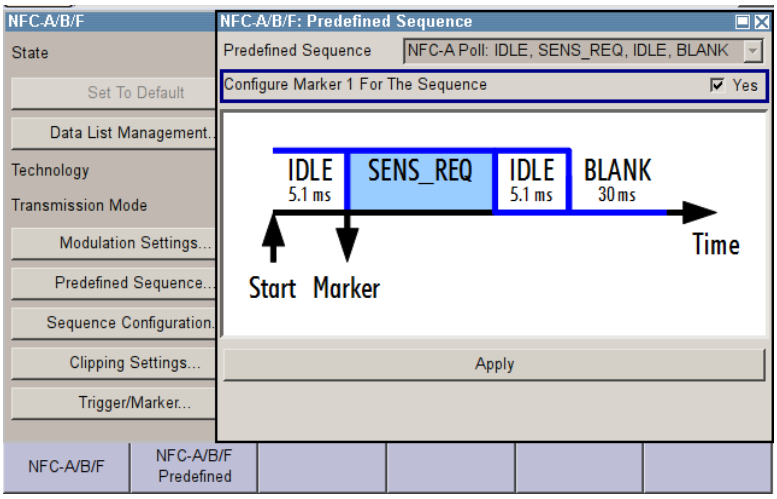


2. Select NFC *A/B/F, Technology: NFC-A* (default), *Transmission Mode: Poll* (default):



4.1.1.1 Using ready to use predefined sequences

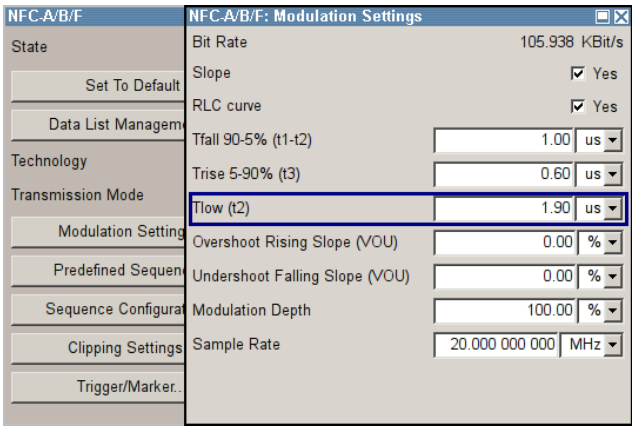
3. Select *Predefined Sequence: NFC-A Poll: IDLE, SENS_REQ, IDLE, BLANK*(default) and select: *Apply*



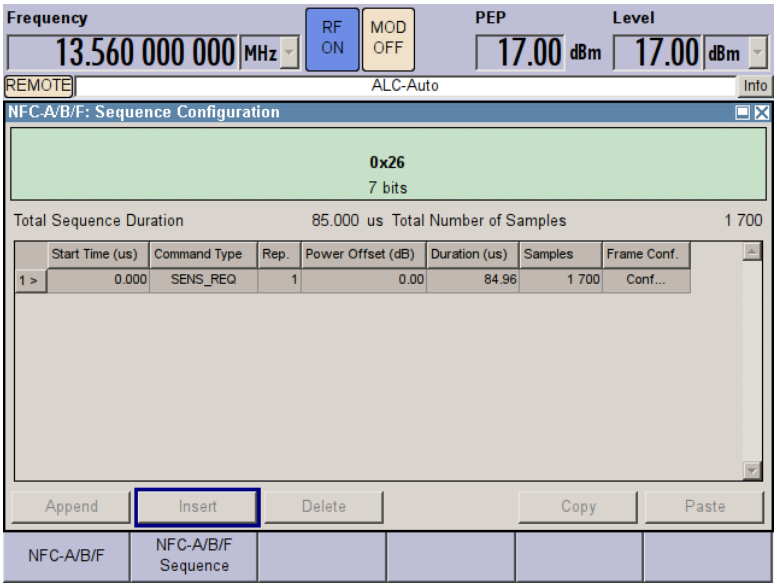
Continue with step 9

4.1.1.2 Alternatively: Setup a sequence manually

4. Check (Edit) NFC-A Timing Parameters by selecting *Modulation Settings.* (The default parameters need to be changed e.g. for testing the receiving characteristic of NFC enabled devices or NFC tags at the limits)

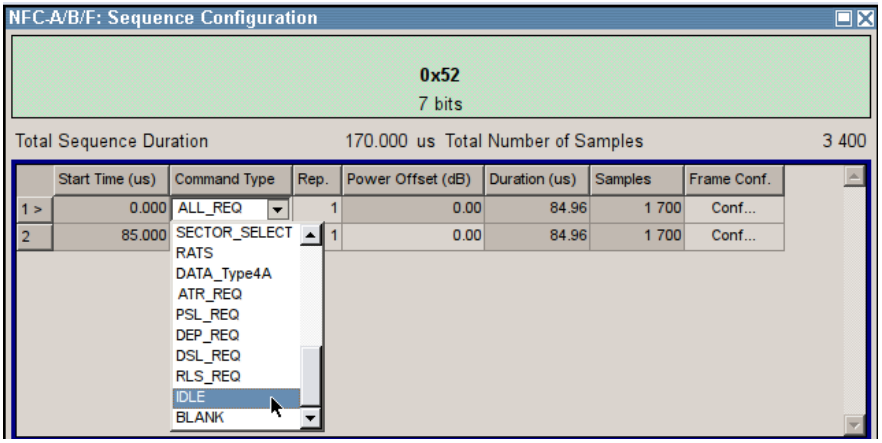


5. Select in *Sequence Configuration*: *SENS_REQ* (default setting)

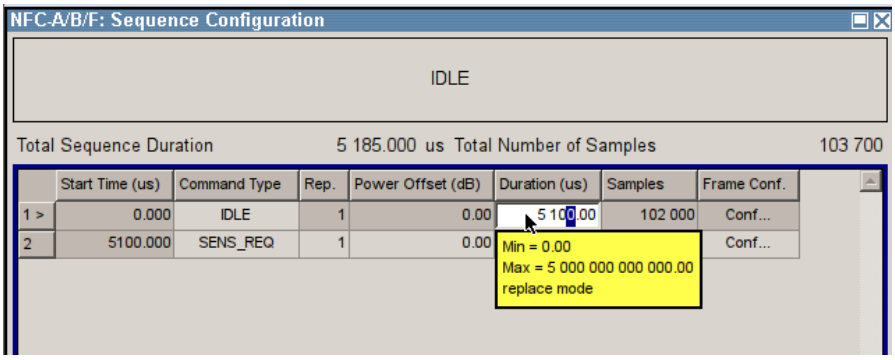


For a useable polling sequence idle signals have to be inserted before and after the SENS_REQ command then concluded by a blank signal.

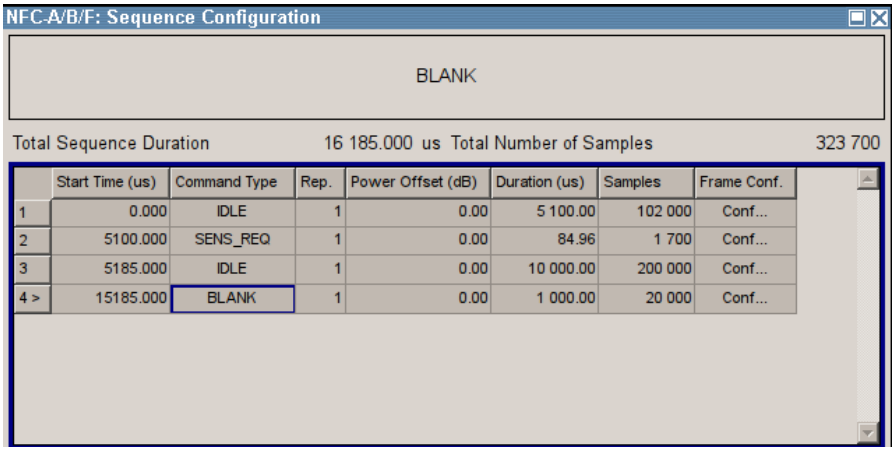
6. Select *INSERT/ IDLE*



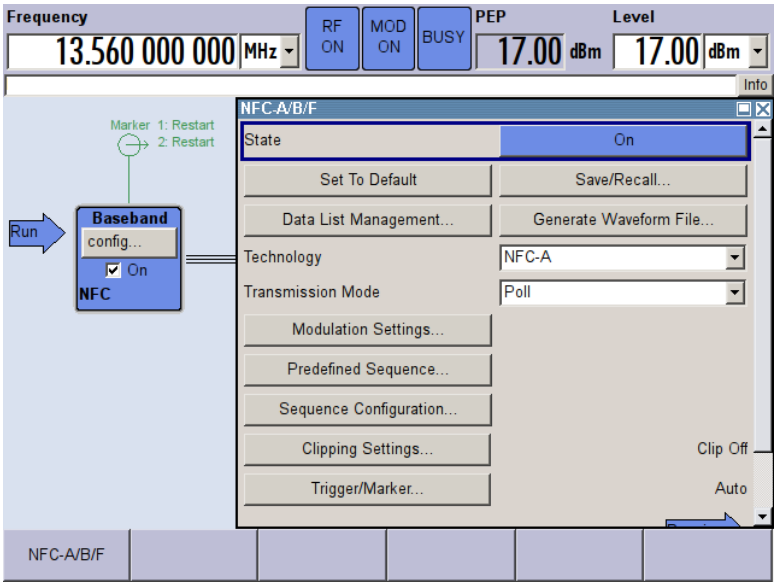
7. Set *Duration* to at least *5000* us



8. Append another *IDLE* signal of 10000 us followed by a *Blank* signal of at least *1000 us*:



9. Switch *NFC-A/B/F State ON*, set *Frequency: 13.56 MHz*, *Level* to at least *17 dBm* and switch *RF ON (Mod On)*

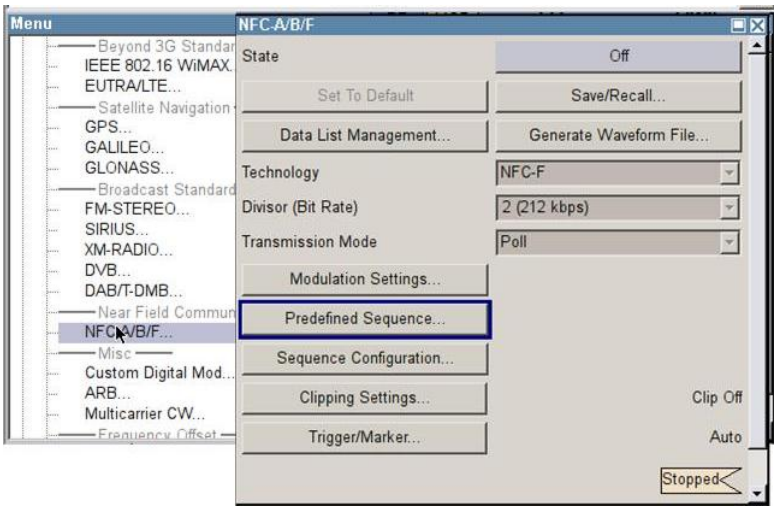


Now the SMBV generates a SENSA_REQ sequence which can be used to stimulate a NFC-A tag or a suitable NFC-enabled phone (Note: Neither the Samsung Galaxy S3 nor Google Nexus S or Sony Xperia P are suitable, they respond only to an SENSF_REQ signal. However there are already different NFC-A tags available that respond to a SENSA_REQ).

4.1.2 Example: Setup an NFC-F poller signal with 212 kB/s

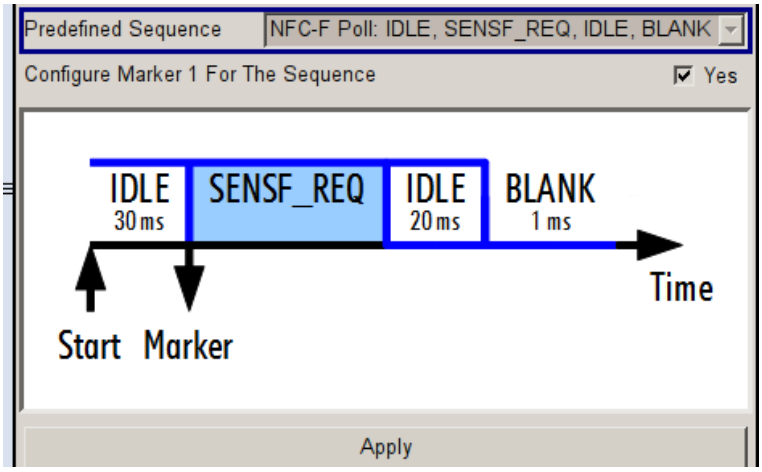
The NFC-A polling sequence previously generated can be modified to an NFC-F poller sequence as shown below.

10. Select *Technology NFC-F: Divisor(Bit Rate): 2 (212kbps)*



11. Select *Predefined Sequence: NFC-F Poll, IDLE, SENSF_REQ, IDLE, BLANK*

12. Press *Apply*



13. Now the SMBV generates a SENSF_REQ sequence which can be used to stimulate a NFC-F tag or a suitable NFC-enabled phone (e.g. the Samsung Galaxy S3, Google Nexus S or Sony Xperia P).

4.2 Examples for executing listener tests

Test Setup shown in chapter 2.3**Fehler! Verweisquelle konnte nicht gefunden werden.** is used for listener tests.

4.2.1 Testing an NFC-A tag

Generate an NFC-A Sens_Req Sequence with SMBV as described in chapter 4.1.1.

Place the NFC-Tag to test on the back of the NFC Reference Poller approximately in the middle of the coil (preferably use Poller 3) as shown below.

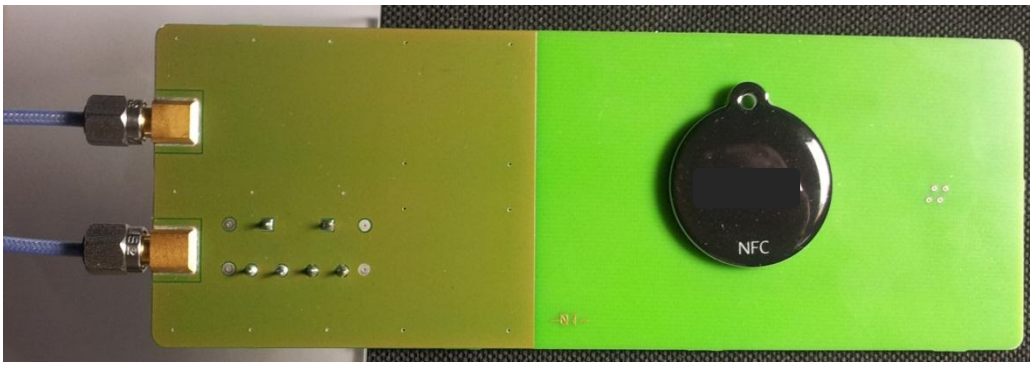


Fig. 4-1: Put the NFC-Tag to test to the back of the NFC Reference Poller approximately to the middle of the coil

Setup the NFC Measurement Software to *NFC-A Trigger*, *Capture Length 25 ms*, *Auto Level Track Time* could be reduced to *100 ms* for increased measurement speed

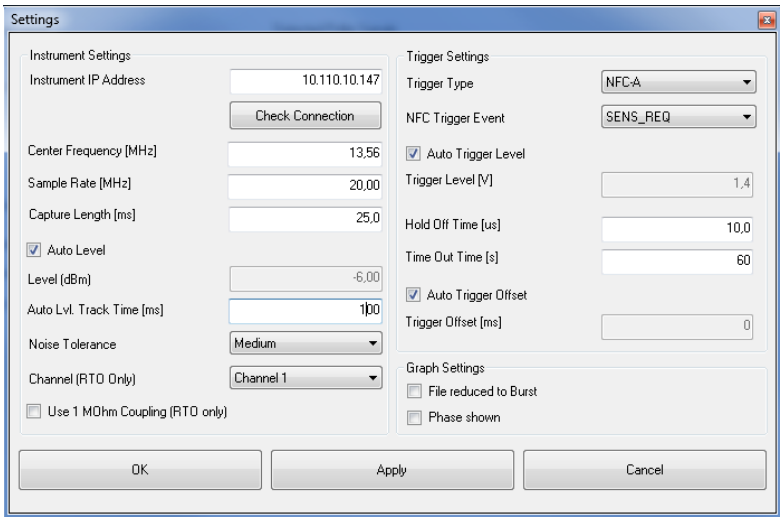


Fig. 4-2: Settings for NFC Measurement Software for Testing an NFC-A tag,

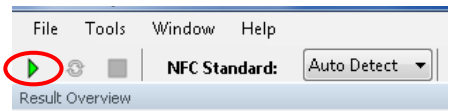


Fig. 4-3: Start measuring with the NFC Measurement Software FS-K112PC by clicking the▶ button

Fig. 4-4 shows a typical result for an NFC-A tag. On the left side the *Result Overview* displays the pass indication for poller RF and Listener RF test and a successful *Functional Test*. On the right side the capture buffer voltage is displayed.

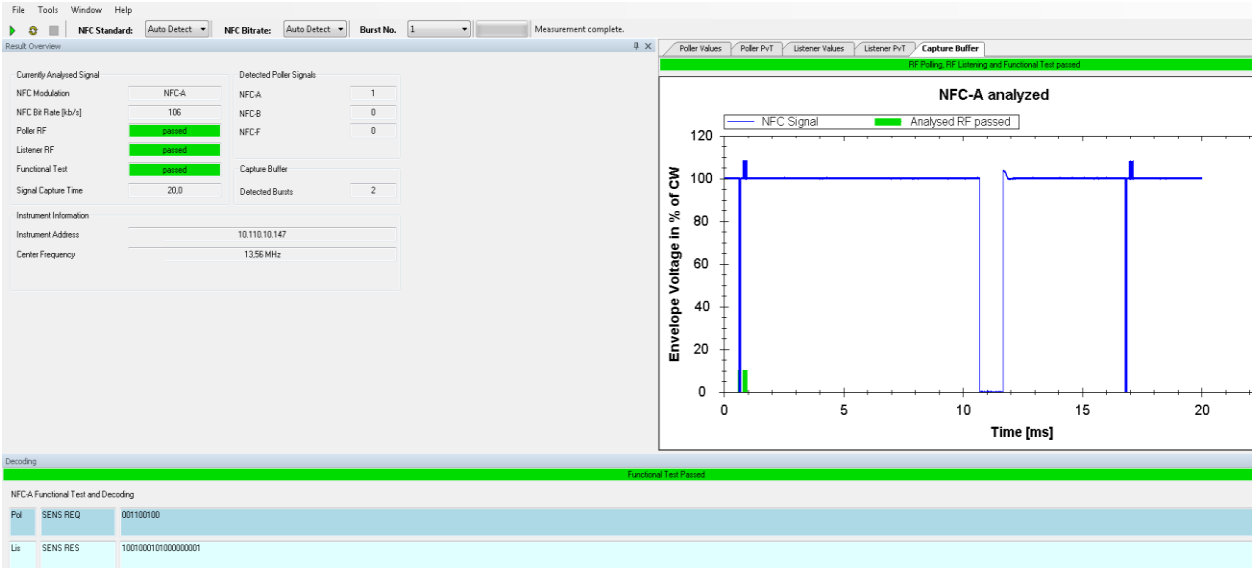


Fig. 4-4: Example of a result for an NFC-A tag (Result Overview and Capture Buffer)

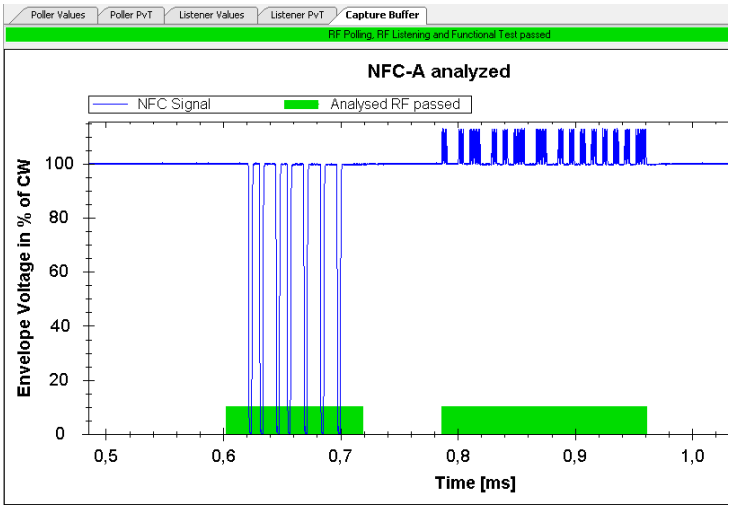


Fig. 4-5: The zoomed part of capture buffer showing in detail a SENSA_REQ signal followed by the SENS_RES answer of the NFC-A Tag

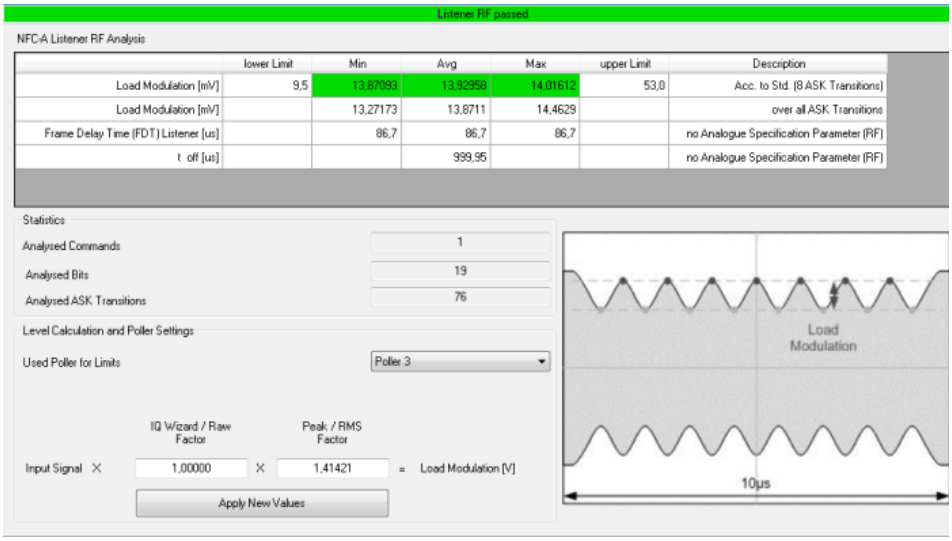


Fig. 4-6: Example of a result for an NFC-A tag, showing in detail the "Listener Values". The measured Load modulation is well above the lower limit of 9.5 mV

4.2.2 Testing an NFC Phone in Listening Mode

Generate an NFC-F 212kB/s Sens_Req Sequence with the SMBV as described in chapter 4.1.2

Place the NFC-Phone to test back to back with the NFC Reference Poller (preferably use poller 3).

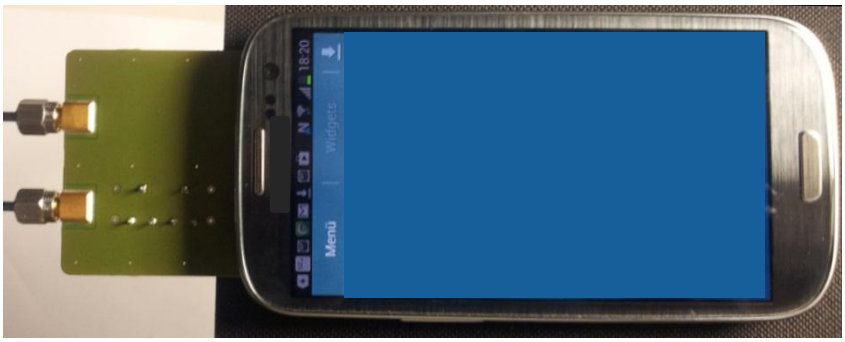


Fig. 4-7: NFC Phone to test back to back with the NFC Reference Poller

Select *Trigger Type NFC-F 212kB/s*

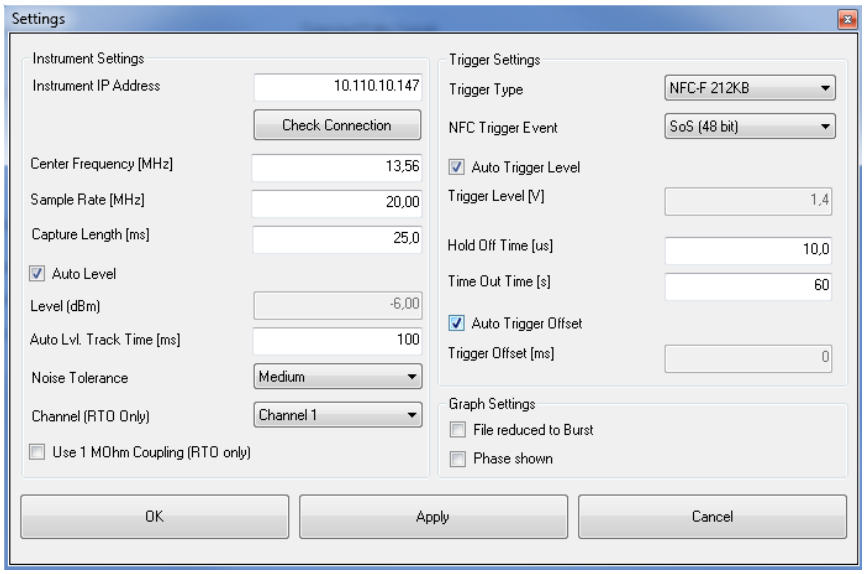


Fig. 4-8: Select Trigger Type NFC-F 212kB/s

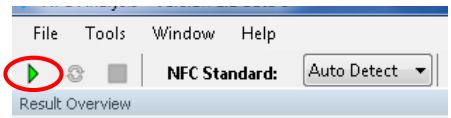


Fig. 4-9: Start measuring with the NFC Measurement Software FS-K112PC by clicking the button

Fig. 4-10 shows a typical result for an NFC-enabled phone. On the left side the *Result Overview* displays the pass indication for *Poller RF* and *Listener RF* test, and a successful *Functional Test*. On the right side the capture buffer voltage is displayed showing the poller signal followed by the listener response of the NFC phone.

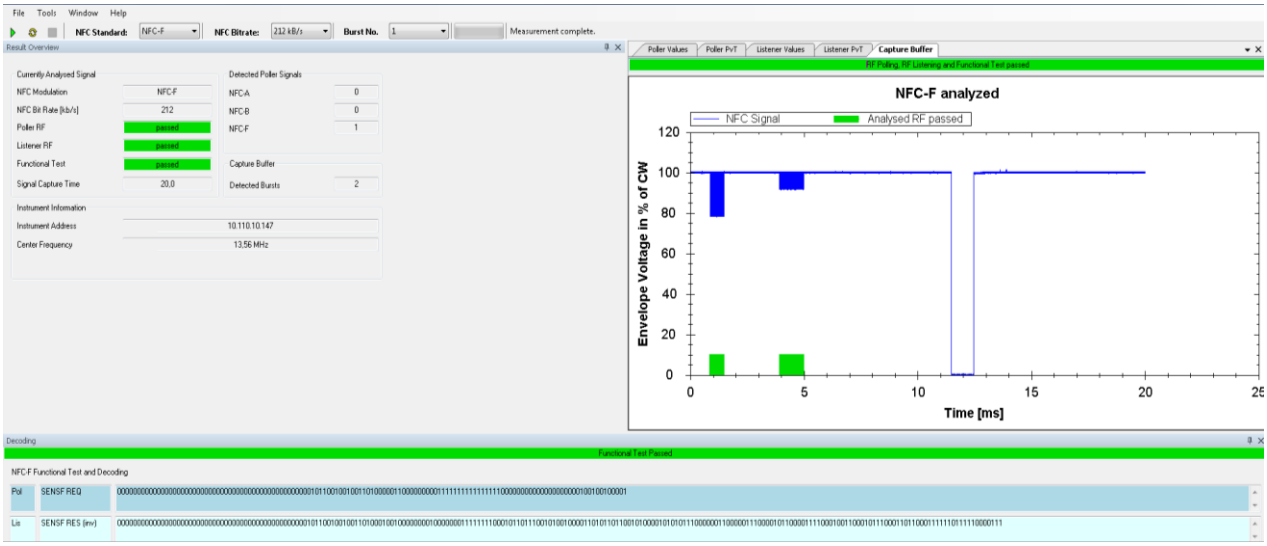


Fig. 4-10: Result for an NFC phone in listening mode, Result Overview and Capture Buffer (Envelope Voltage in % of CW over Time)

5 Literature

[1] NFC Analog Specification Analog 1.0, NFC Forum™

[2] Roland Minihold, 1Ma182 “Near Field Communication(NFC) Technology and Measurements”, White Paper

6 Additional Information

This Application Note is subject to improvements and extensions. Please visit our website in order to download new versions. Please send any comments or suggestions about this Application Note to TM-Applications@rohde-schwarz.com.

7 Ordering Information

Ordering Information		
Vector Signal Generator		
R&S®SMBV100A	Vector Signal Generator	1407.6004.02
R&S®SMBV-B103 [1)]	RF 9 kHz – 3.2GHz	1407.9603.02
R&S®SMBV-B10	Baseband Generator with Digital Modulation (real-time) and ARB (32 Msample), 120 MHz RF BW	1407.8607.04
R&S®SMBV-B92	Hard Disk (removable)	1407.9403.02
R&S®SMBV-K89	Digital Standard NFC-A/B/F	1419.1690.02
Digital Oscilloscope		
R&S®RTO1002 [2)]	600 MHz, 10 Gsample/s 20/40 Msample, 2 channels	1316.1000.02
R&S®RTO-K11	I/Q Software Interface	1317.2975.02
Probe		
R&S®RT-ZP10	500 MHz, passive, 10:1, 1 MΩ, 9.5 pF, max. 400V	1409.7550.00
R&S®RT-ZA10	SMA Adapter	1416.0457.02
NFC Test Antennas		
R&S®CSNFC-B8	NFC Forum Reference Equipment	1519.5096.02
Measurement Software		
R&S®FS-K112PC	NFC Measurement Software	1310.0448.06
R&S®FSPC	License Dongle	1310.0002.03
Signal Analyzers		
R&S®FSL3 [1)]	Spectrum Analyzer	1300.2502.03
R&S®FSV7 [1)]	Signal and Spectrum Analyzer	1307.9002.03

Ordering Information		
R&S®FSW8 [1)]	Signal and Spectrum Analyzer, 2 Hz to 8 GHz	1312.8000.08
R&S®ZVL3 [1)]	Vector Network Analyzer	1303.6509.03
R&S®ZVL-K1	Spectrum Analysis Option	1306.0301.02

1) Basic model. Models with higher upper frequency range are also suitable.

2) Basic model. Models with higher upper frequency range and more channels are also suitable

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ISO 9001

PAD-T-M: 3573.7380.02/02.00/CI/1/EN/

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