R&S®FS-K112PC
NFC Measurement Software
User Manual

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Test & Measurement

User Manual

ROHDE&SCHWARZ

This manual covers the following products:

- R&S®FS-K112PC (1310.0448.02)

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The following abbreviations are used throughout this manual: R&S®K112PC is abbreviated as R&S FS-K112PC.

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Contents

1 Preface

1.1 Documentation Overview

The user documentation for the R&S FS-K112PC consists of the following parts:

- Documentation CD-ROM with:
  – User Manual
  – Release Notes
  – Data sheet and product brochures

User Manual

The user manual is available in PDF format - in printable form - on the Documentation CD-ROM delivered with the software. In the user manual, all software functions are described in detail. Furthermore, it provides a complete description of the remote control commands.

Release Notes

The release notes describe new and modified functions, eliminated problems, and last minute changes to the documentation. The corresponding firmware version is indicated on the title page of the release notes. The most recent release notes are provided on the internet.

1.2 Conventions Used in the Documentation

Typographical Conventions

The following text markers are used throughout this documentation:

Convention	Description
"Graphical user interface elements"	All names of graphical user interface elements on the screen, such as dialog boxes, menus, options, buttons, and softkeys are enclosed by quotation marks.
KEYS	Key names are written in capital letters.
`File names, commands, program code`	File names, commands, coding samples and screen output are distinguished by their font.
Input	Input to be entered by the user is displayed in italics.
Links	Links that you can click are displayed in blue font.
"References"	References to other parts of the documentation are enclosed by quotation marks.

2 Welcome to the NFC Measurement Software

2.1 Installing R&S FS-K112PC

Successful installation of the program requires two steps.

- Installing Required Components
- Installing R&S FS-K112PC

2.1.1 Installing Required Components

The software requires the installation of several components to run properly. All of these components are delivered with the software package. Thus, you can install them directly from the CD-ROM prior to installing the software itself.

Required software components

- Microsoft .NET Framework 2.0
- VISA

If the required components are already installed on your computer, you can skip this step.

Installing Microsoft .NET Framework 2.0

The R&S FS-K112PC requires the installation of Microsoft .NET Framework 2.0 or later.

Check if .NET Framework is already installed.

1. Navigate to the installation location (usually the CD-ROM drive).
2. Start `\Install\Framework\Microsoft .NET Framework 2.0\Check for .NET Installed.exe`

   The file checks if .NET Framework is installed or not.
3. If not, start `\Install\Framework\Microsoft .NET Framework 2.0\dotnetfx.exe` and follow the instructions.

Install VISA

It is also necessary to install VISA (Virtual Instrument Software Architecture) to access instruments connected to the PC via IEEE or LAN bus. It is then possible to remote control the measurement instrument.

You can use both National Instruments and Agilent VISA.

- The National Instrument VISA driver CD is supplied together with the R&S FS-K112PC software package. You can also visit http://www.ni.com/visa to get the latest version for your operating system if you are licensed to.

- If you are using an Agilent hardware or need to use the Agilent VISA, visit http://www.agilent.com to get the latest version for your operating system.

2.1.2 Installing R&S FS-K112PC

After installing all required components, you can install the R&S FS-K112PC. The installer will do the following:

- Install the R&S FS-K112PC software including an uninstall tool
- Create a Windows Start Menu entry (Programs ⇨ R&S NFC Analysis)
- Create a shortcut on the desktop (optional)
- If necessary (the software will specifically ask you to), set the required environment variables.

Start the software via the Windows "Start Menu" entry or the shortcut on the desktop.

2.1.3 Deinstalling R&S FS-K112PC

You can uninstall the software itself via the uninstall tool available in the Windows "Start Menu" folder or via "Add or Remove Software" in the Windows "Control Panel".

The Framework components have to be uninstalled manually via "Add or Remove Software" in the Windows "Control Panel".

Before uninstalling the components, make sure that no other software uses one of the components.

The following components and programs have been installed:

- Microsoft .NET Framework 2.0
- R&S Port Mapper
- Rohde & Schwarz NFC Analysis (R&S FS-K112PC)

2.2 Using the Smart Card Reader

The software is licensed by a smart card licensing system. This licensing system requires a smart card to be connected to the PC when you are using the software. The smart card and dongle are available as separate products.

You can connect the smart card in two ways.

- Connect the smart card in SIM format.
  If you want to connect the smart card in SIM format, use the USB smart card reader that is included in the delivery of the software.
- Connect the smart card in its full format.
  If you want to connect the smart card in full format, an interface compatible to the card format is required.

The following devices are able to read the smart card in full format.

- smart card reader integrated in a keyboard
- smart card reader integrated in a notebook
- smart card reader integrated in a desktop PC (e.g. OMNIKEY)
- smart card reader connected to the computer via serial bus or USB (e.g. OMNIKEY)
- USB reader connected to a LAN-to-USB converter to distribute the license via the network (e.g DIGI AnaywhereUSB/2)

Licensing support

If you have any difficulties with the licensing system, support is only assured when you are using the USB smart card reader that is delivered with the smart card.

Using the USB smart card reader

1. Included in the delivery of the software is the smart card in full format and a smart card reader.

2. Break out the smart card in SIM format.

3. Insert the smart card into the smart card reader.

a) Turn the smart card reader in a way that the OMNIKEY label faces upward.
b) Insert the smart card with the chip face down and the angled corner facing away from the reader.

4. Push the smart card into the reader as far as possible.

   The smart card reader is ready for use on any USB interface.

   When you connect the reader to the computer, MS Windows automatically installs the necessary drivers. If not, you can install the drivers manually from the software CD. The required files are stored in the directory `\Install\USB SmartCard Reader Driver Files`. The driver files are named according to the processor architecure for which they are designed. (`OMNIKEY3x21_x86` or `OMNIKEY3x21_x64`).
   Information on drivers and driver updates are also included in the `ReadMe.txt` file in the same directory as the drivers.

Locking the computer

If you have difficulties unlocking the computer while the smart card is connected because MS Windows tries to get log-in information from the card after you have locked the computer.

You can solve this issue by editing the system registry.

Automatic change

► Run `DisableCAD.reg` to change the registry entry automatically.
The file is in the same directory as the driver files.

Manual change

1. Open the Windows "Start Menu" and select the "Run" item.
2. Enter `regedit` into the dialog box to open the system registry.
3. Look for `HKEY_LOCAL_MACHINE\SOFTWARE\Microsoft\Windows\CurrentVersion\policies\system`.
4. Set the value of `DisableCad` to 0.

Administration rights

Security policies of your network environment might prevent you from editing the system registry or installing drivers. Contact your IT administration in that case.

2.3 Starting the Software

► Start the software with the desktop icon or select "Programs" ⇨ "R&S NFC Analysis" in the Windows "Start Menu"

The user interface (GUI) of the software opens.

Software user interface

Basically, the user interface consists of these elements

- a menu bar that provides access to the software functionality at the top
- a toolbar that provides easy access to the most important functions
- a workspace

In the initial state, the software shows the Result Overview, the Decoding results and the Poller Values. All other result displays are added to the Poller Values result displays as tabs. For more information on available result displays see chapter 3, "Measurements and Result Displays", on page 18.

If you want another layout of the workspace, you can customize its layout. For more information see chapter 2.4, "Customizing the User Interface", on page 14.

Adding or removing windows from the workspace

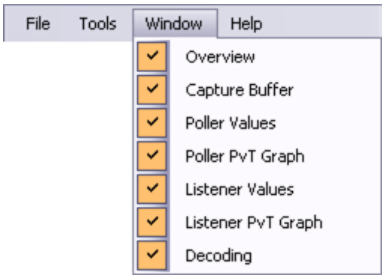
The R&S FS-K112PC provides several types of windows.

- Result displays contain the measurement results of the NFC analysis. The R&S FS-K112PC provides several result displays, each containing a set of related results.
- The "Settings" dialog contains functionality to configure the measurement.

You can add as many different windows to the workspace as you want, but each type of window only once.

► Select the "Window" item in the menu bar.

The software opens a dropdown menu to add or remove windows.



To add a window, just select the corresponding entry in the dropdown menu (☑).

To remove a window, deselect the corresponding entry in the dropdown menu ( ) or close it with the ☒ button.

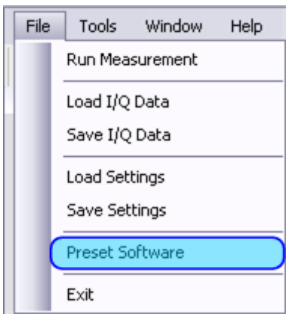
Hidden tabs

If the ▾ icon is visible in one of the window frames, there are hidden tabs that don't fit in the user interface. If you click on the icon, a list of all active tabs in that window opens.

Performing a preset

All settings have been assigned predefined values that you can restore anytime you need.

► Select the "Preset" menu item from the "File" menu.



The software restores the predefined values for all settings.
SCPI command:
`SYSTem:PRESet` on page 53

Measuring signals

When you start the software, it assumes that it gets the data from an instrument (spectrum analyzer or oscilloscope) that is connected to the PC via TCP/IP. In that case, the software records and evaluates the I/Q data live from the measurement equipment.

Currently, the software supports the use of the following instruments:

- R&S FSL (spectrum analyzer)
- R&S FSV (signal analyzer)
- R&S ZVL (network analyzer)
- R&S RTO (oscilloscope)

► Press the ▶ and ■ buttons in the toolbar to start or stop a measurement.
Note that the button initiates the recording of the I/Q data. Current I/Q data is lost. The amount of I/Q data depends on the "Capture Length" you have defined. For more information see chapter 4.3, "Configuring the Measurement Equipment", on page 40.

SCPI command:
`INITiate[:IMMediate]` on page 51

► Press the button to evaluate the I/Q data currently in the capture buffer again.

Refreshing the results is useful if you want to evaluate the I/Q data with different settings, for example.

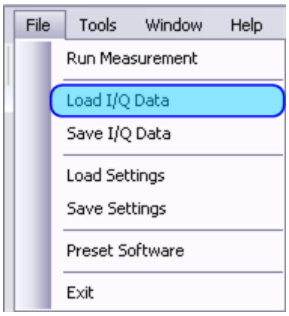
SCPI command:
INITiate:REFResh on page 51

Alternatively to a live recording you can restore previously recorded I/Q data from a file and evaluate that I/Q data again.

Importing signal data

If you have a recorded set of I/Q data stored in a file with the file extension *.iq.tar, you can load it into the software.

► Select the "Load I/Q Data" menu item from the "File" menu.



The software opens a dialog box to select the file. The file must have the .iq.tar format.
SCPI command:
MMEMory:NFC:LOAD:IQ on page 52

After you have opened the file, the software analyzes the data that the file contains automatically.

The iq.tar file format

An .iq.tar file contains I/Q data in binary format together with meta information that describes the nature and the source of data, e.g. the sample rate. The objective of the .iq.tar file format is to separate I/Q data from the meta information while still having both inside one file. In addition, the file format allows you to include customized data.

An .iq.tar file must contain the following files.

- I/Q parameter .xml file
  Contains meta information about the I/Q data (e.g. sample rate). The filename can be defined freely, but there must be only one single I/Q parameter .xml file inside an .iq.tar file.
- I/Q data binary file
  Contains the binary I/Q data of all channels. There must be only one single I/Q data binary file inside an .iq.tar file.

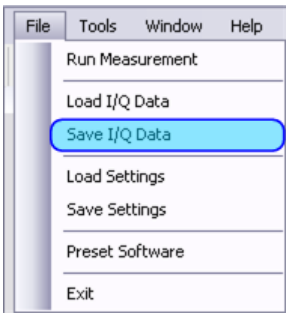
Optionally, an .iq.tar file can contain the following file.

- I/Q preview .xslt file
  Contains a stylesheet to display the I/Q parameter .xml file and a preview of the I/Q data in a web browser.

Exporting signal data

When you have recorded I/Q data that you want to have access to later, the software allows you to export the I/Q data to a file.

► Select the "Save I/Q Data" menu item from the "File" menu.



The software opens a dialog box to define the name and target folder of the file. Note that the file extension you have to use is *.iq.tar.

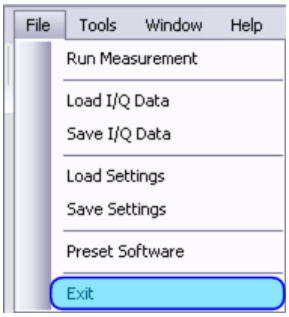
SCPI command:

`MMEMory:NFC:STORe:IQ` on page 53

When you save the signal to a file you can load and view it again anytime you want (see "Importing signal data" on page 12).

Exiting the software

► Select the "Exit" menu item from the "File" menu.

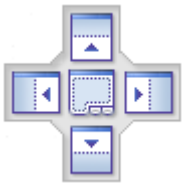


2.4 Customizing the User Interface

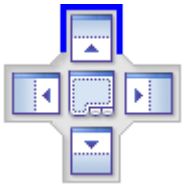
In addition to adding and removing elements to and from the workspace, you can also customize the layout of the user interface by docking elements to a particular position of the working area, by adding a tab to an existing element or by altogether removing an element from the user interface.

2.4.1 Docking Elements

1. Select an element in the title bar with the mouse and move it around until a docking spot appears.
   Docking spots look like this:



2. Move the mouse cursor over one of the possible docking spots.
   The border of the docking spot turns blue. The screen area in which the element will be positioned also turns blue.



3. Release the element.
   The element docks itself to the corresponding area of the GUI.

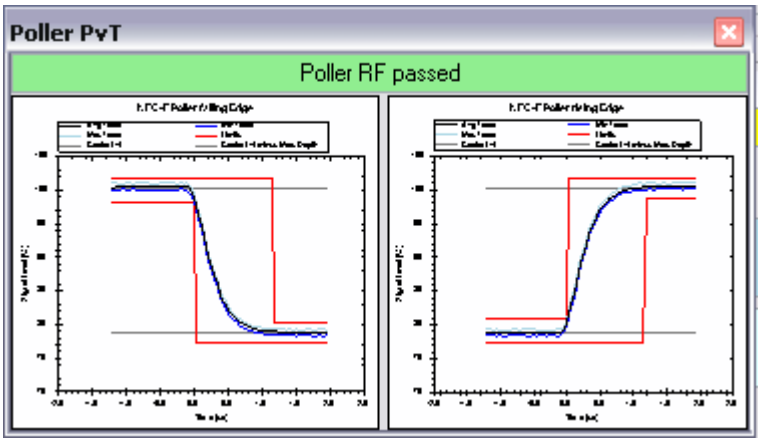
2.4.2 Adding an Element as a Tab

1. Select an element with the mouse and move it over the center docking spot in an area where another element already is.
2. Release the element.
   The released element is added as a tab to the element.

   The active tab always is in a lighter color than the others.
   Note that tabs may be at the top of the window or at the bottom of the window, depending on where the window is in the user interface.
3. Select the tab you need by either clicking on the tab itself or by clicking on the ▾ symbol and selecting the tab you need from the list.

2.4.3 Removing an Element from the GUI

► Select an element with the mouse, move it around and release it.
If you haven't docked the element or added it as a tab, it is floating around as an individual window. You can also move the element completely out of the GUI and work with it in an independent window (e.g. another monitor).



2.5 Connecting the Software to an Instrument

In order to be able to communicate with an analyzer, you have to connect it to the software in a local area network (LAN).

For more information on supported instruments see "Measuring signals" on page 11.

Requirements

To be able to capture signal data, you need one of the instruments mentioned above.

To establish a connection, you also have to determine the network address of the instruments and set it up in the software.

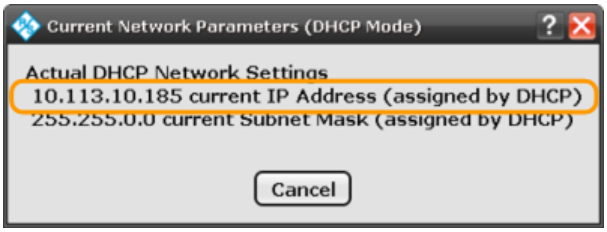
For more information on including the instrument configuration in the software see chapter 4.3, "Configuring the Measurement Equipment", on page 40.

2.5.1 Figuring Out the Address of an R&S FSV

Follow these steps to figure out the network address of an R&S FSV.

1. Press the SETUP key.
2. Press the "General Setup" softkey.
3. Press the "Network Address" softkey.
4. Press the "IP Address" softkey.

   The R&S FSV opens a dialog box that contains information about the LAN connection.

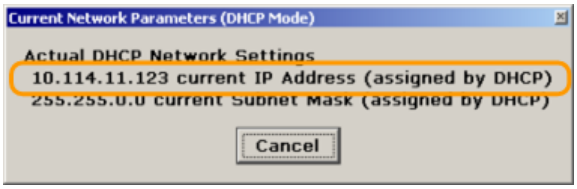


2.5.2 Figuring Out the Address of an R&S FSL or R&S ZVL

Follow these steps to figure out the network address of an R&S FSL or R&S ZVL.

1. Press the SETUP key.
2. Press the "General Setup" softkey.
3. Press the "Network Address" softkey.
4. Press the "IP Address" softkey.

   The analyzer opens a dialog box that contains information about the LAN connection.

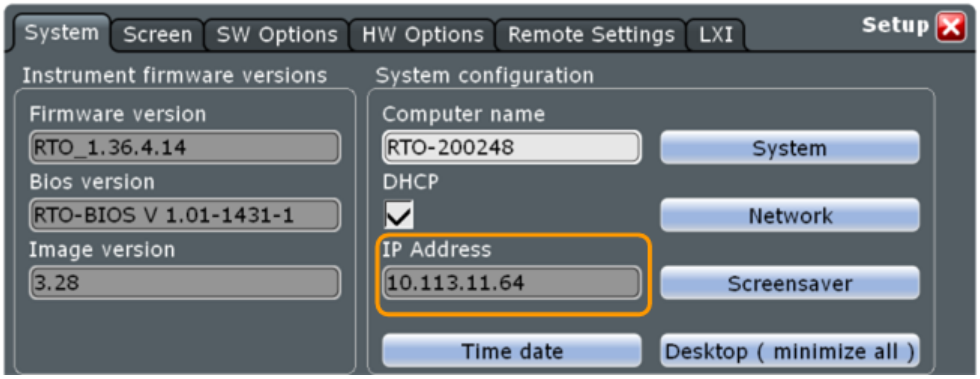


2.5.3 Figuring Out the Address of an R&S RTO

Follow these steps to figure out the network address of an R&S RTO.

► Press the SETUP key.

The R&S RTO opens a dialog box that contains general information about the system.



3 Measurements and Result Displays

After the software has evaluated the I/Q data, you can display the test results in various graphical and numerical result displays.

Quick evaluation of test results

Each result display has a colored bar at the top that displays the test results so that you can see at a quick glance if the test has passed or failed.

The results are highlighted depending on the quality of the signal (and provided that the software could find an actual NFC signal in the I/Q data).

- green highlighting

  Listener RF passed

  The test has passed. The signal complies to the specifications defined by the NFC Forum.
- yellow highlighting

  RF Polling, RF Listening and Functional Test partly passed and partly failed

  The test has passed in parts. However, something did not comply to the specifications defined by the NFC Forum (e.g. if the listener has passed the test, but the poller did not).
- red highlighting

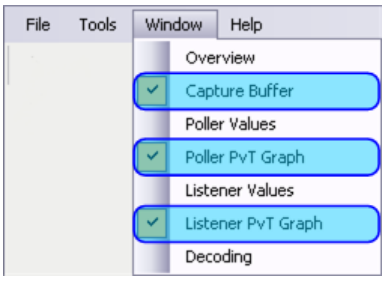
  Functional Test failed

  The test has failed completely. No signal parts comply to the specifications defined by the NFC Forum or the software was not able to process the data as expected.
- no highlighting
  The software could not detect an NFC signal in the I/Q data.

3.1 Graphical Results

The graphical displays are basically a representation of the signal power against a particular period of time.

► Select the "Capture Buffer", the "Poller PvT Graph" or the "Listener PvT Graph" item from the "Windows" menu.



The software opens the corresponding windows and displays the results if you have previously performed a measurement.

3.1.1 Capture Buffer

The "Capture Buffer" result display shows the power level of the complete I/Q data stored in the capture buffer. The size of the capture buffer depends on the capture length you have defined (see chapter 4, "Configuration", on page 38).

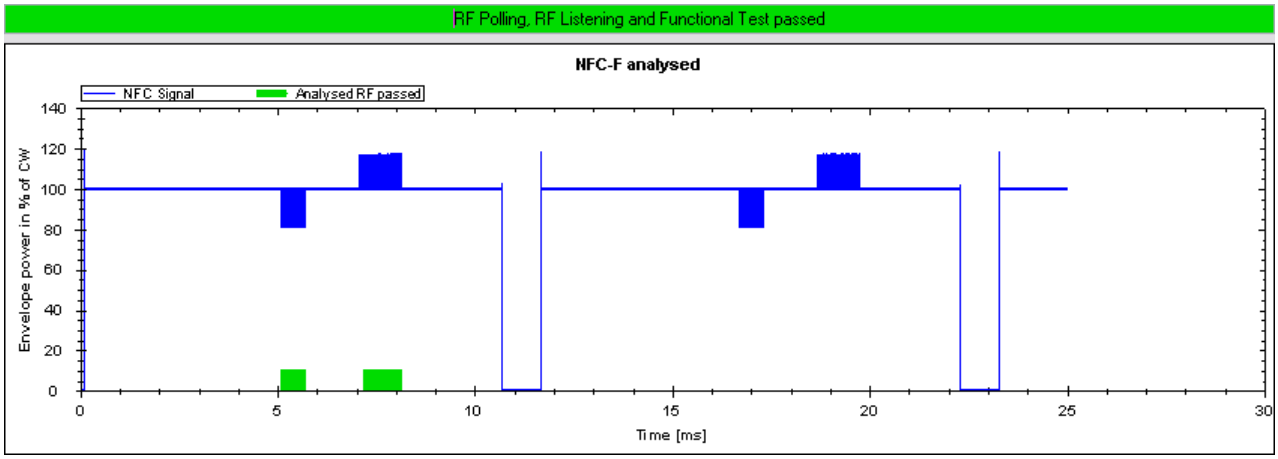
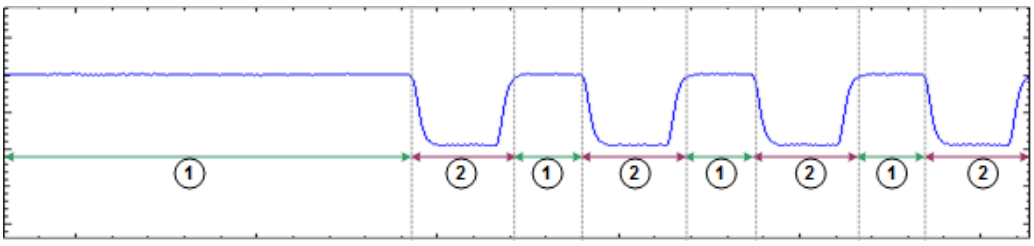


Fig. 3-1: Capture buffer containing the I/Q data of an NFC-F signal (based on example file NFC-F_212kB_Example.iq.tar)

The software calculates and shows the power of the signal in relative to the level of the carrier signal transmitted by the poller. The carrier signal is a continuous wave. The carrier signal is normalized to 100 %. The power level is displayed on the left diagram axis.

When two NFC devices exchange data, the carrier signal supplied by the poller is modulated for a particular amount of time (the 'low state transition' in case of poller signals and 'load modulation' in case of listener signals). During this time, the signal level of the carrier signal drops or rises by a certain amount. You can see the taps into the power by the shape of the trace.



1 = carrier signal, power = 100 %
2 = low state transition, power = < 10 % of the modulation depth (poller signal)
2 = load modulation, power ≠ 100 % (listener signal, not shown)

In order to synchronize to the signal, the software looks for a poller request. A poller request consists of a set of low state transitions, whose characteristics depend on the modulation type. A set of low state transitions in that context is also referred to as a burst.

When the software is synchronized to the signal, it tries to analyze and demodulate all bursts that it finds in the capture buffer (poller and listener communication).

Note that the software only analyzes bursts of one NFC modulation type at a time. Therefore, it analyzes subsequent bursts only if they are of the same modulation type as the first detected modulation type (automatic detection) or if they are of the modulation type you have selected manually from the toolbar.

After the analysis of the NFC bursts is done, the software shows the results for each burst of the same modulation type as a colored bar at the bottom of the diagram.

- Green bar
  Signal areas where an (NFC) signal has been detected and analyzed. The signal complies to the specifications by the NFC Forum.
- Grey bar
  Signal areas where an (NFC) signal has been detected, but not analyzed because the signal does not comply to the currently selected modulation type.
- Red bar
  Signal areas where an (NFC) signal has been detected and analyzed. The signal, however, does not comply to the currently selected modulation type.

However, even if the signal is a valid NFC signal, demodulation might not be possible. This may be the case if, for example, the selected modulation type does not match the modulation type of the signal.

The figure below shows the same signal in both diagrams. In the left picture, the signal has not been evaluated because the selected modulation type does not match the signal modulation type. The software shows a grey bar. If the selected modulation type matches that of the signal, the demodulation did work and the signal is marked by a green bar.

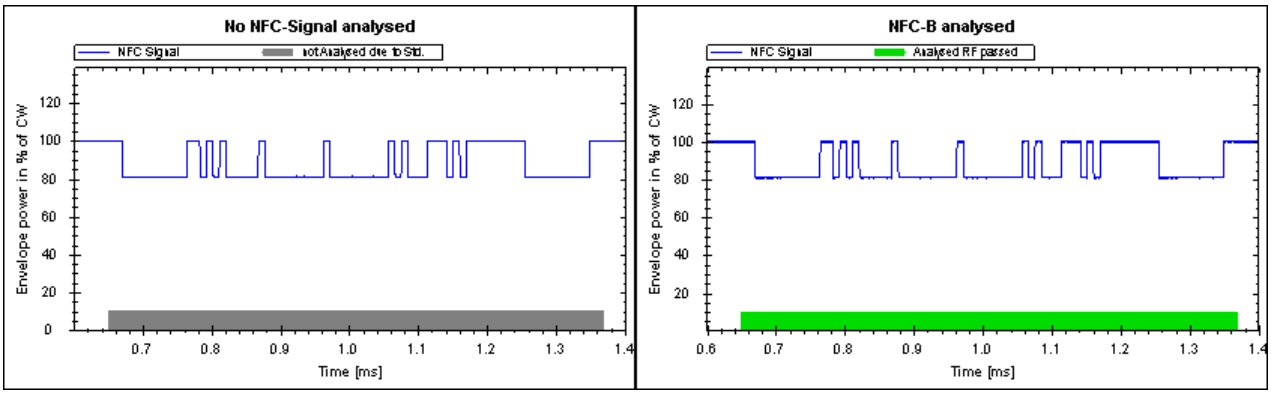


Fig. 3-2: NFC-B signal with NFC-A selected (left) and NFC-B selected (right) (based on example file NFC-B_Example.iq.tar)

The result display also shows the phase oscillation in the diagram as a red line when you turn on the display of the phase characteristics (see "Phase Shown" on page 44). In that case, the right vertical diagram axis represents the scale of the phase display.

3.1.2 Poller Characteristics

The "Poller PvT" result display shows the level characteristics of the NFC poller over the period of exactly one low state transition. It also shows if the low state transition is within the limits defined by the NFC Forum graphically.

Basically, a poller transmission consists of several low state transitions. During a low state transition, the power drops to a lower level than the carrier signal. The number of low state transitions in the signal depends on the amount of bits that are transmitted.

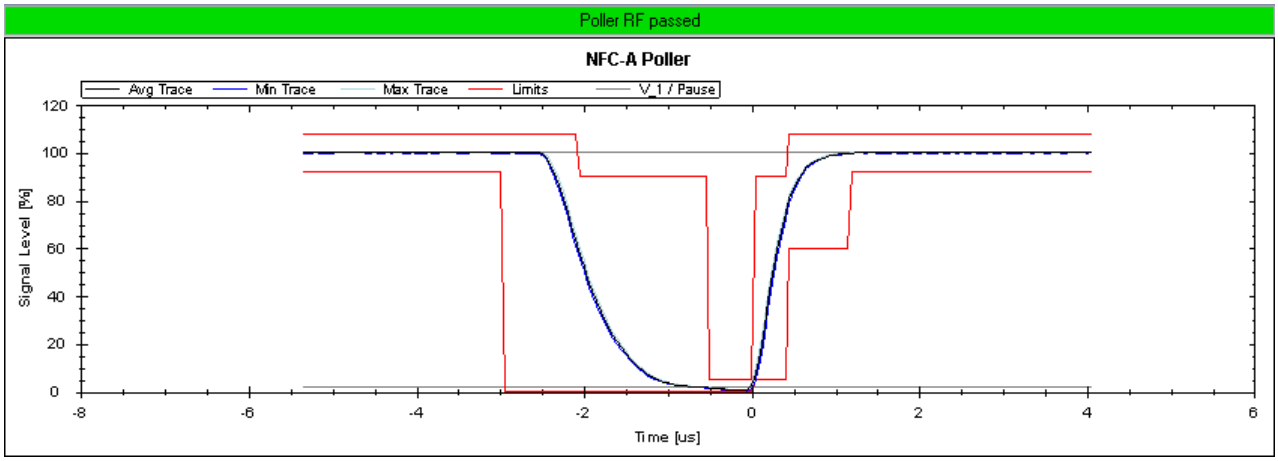


Fig. 3-3: NFC-A poller signal (based on example file NFC-A_Example.iq.tar)

Viewing all low state transitions

If you want to see all low state transitions of the transmission, use the "Capture Buffer" result display.

The displayed power is the power of the signal in % of the carrier signal transmitted by the poller. The carrier signal is normalized to 100 %.

Note that the result display consists of two panes in case of NFC-B and NFC-F signals.

- The left pane shows the falling edge of the low state transition.
- The right pane shows the rising edge of the low state transition.

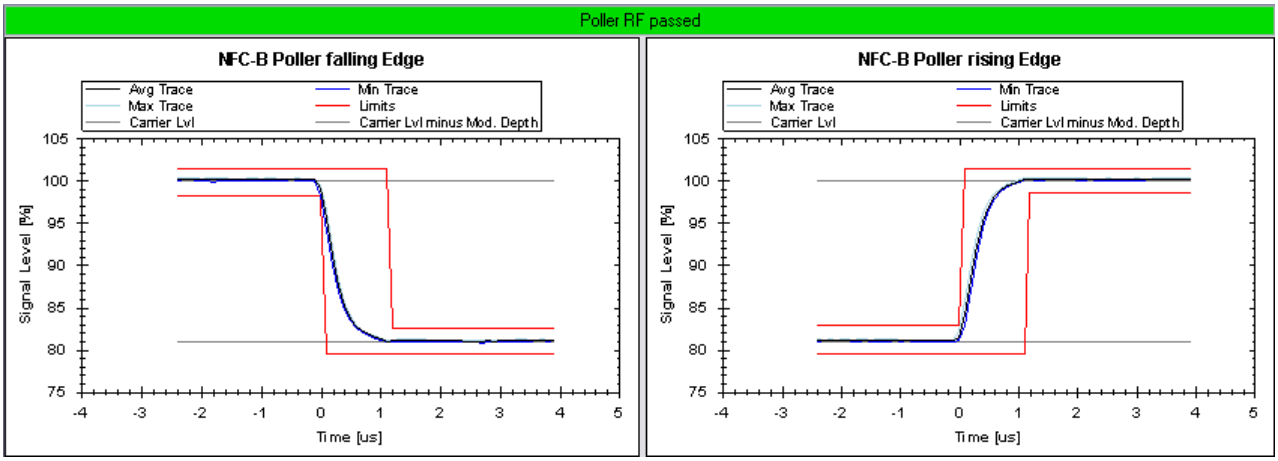


Fig. 3-4: NFC-B poller signal (based on example file NFC-B_Example.iq.tar); NFC-F looks similar

Compared to NFC-A, NFC-B and NFC-F do not define limits for the duration of the low state transition. Limits are only defined for the rising and falling edges. Thus, the scale of the horizontal axis is variable for these modulation types and the R&S FS-K112PC only shows the falling and rising edges.

For NFC-A, the limits and duration of the transition are fix. Therefore, the scale of the horizontal axis is also fix.

The result display contains several lines, distinguished by colors. For a quick assessment of the contents of the result display, it includes a key to the colors above the diagram.

- Red lines
  The red lines are the upper and lower limits defined by the NFC Forum. If the signal complies to the specified limits, all RF traces have to be within the two red lines. If one of the signal traces violates the limits, the RF test fails.
  In case of NFC-A signals, the limits not only define the power charcateristics that the signal should have, but also the duration of the transmission.
- Grey lines
  The grey lines indicate the modulation depth.
  The modulation depth is the magnitude of the power drop during the low state transition. The modulation depth is a percentage with the carrier signal being 100%.
  The modulation index defined for NFC-B and NFC-F also represents the power drop during the low state transitions, but is a ratio of voltages at defined locations of the transition.

  $$m_i = \frac{V_a - V_b}{V_a + V_b}$$

  with V_a being the high amplitude and V_b being the low amplitude.
- Blue, black and green traces
  The blue, black and green traces show the level characteristics of the poller signal over time. The displayed time is a little longer than one NFC low state transition lasts. The different colors represent different evaluation methods.
  – The blue trace represents the minimum power that has been measured for all transitions during the transmission.

– The light green trace represents the maximum power that has been measured for all transitions during the transmission.
– The black trace represents the average power of all transitions during the transmission.

The number of low state transitions included in the evaluation of the minimum, maximum and average power depends on the amount of information contained in the poller request.

Example:

In case of the signal shown below (from the "Capture Buffer" result display), the software would include seven low state transitions in the evaluation of the minimum, maximum and average traces.

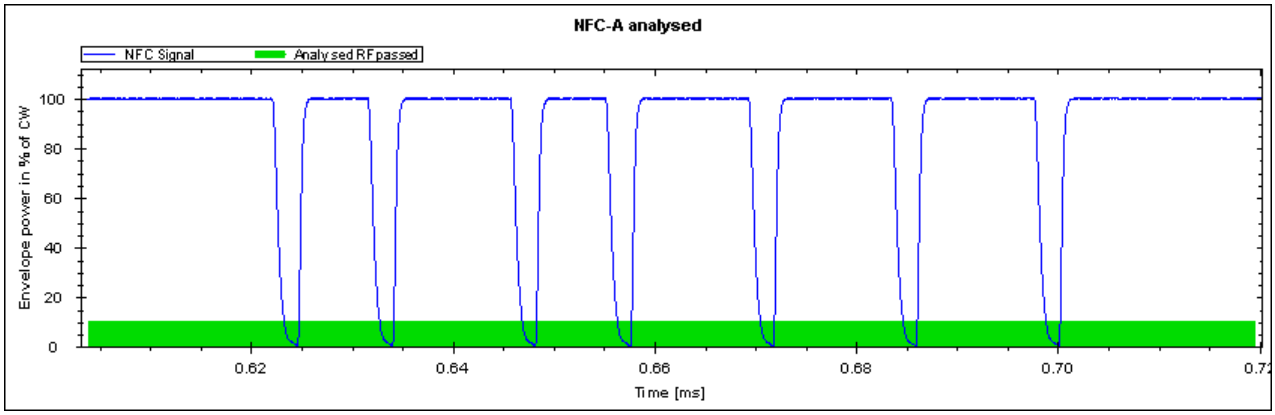


Fig. 3-5: Several NFC-A low state transitions (based on example file NFC-A_Example.iq.tar)

3.1.3 Listener Characteristics

The "Listener PvT" result display shows the level characteristics (load modulation) of the NFC listener over the period of the transmission.

The listening device is a passive device that draws its power from the carrier signal that the NFC poller generates. This passive use of power from an external device is called load modulation, whose characteristics are the main focus when testing the listening device.

In case of NFC-A signals, the result display consist of two panes, both showing the load modulation.

- The left pane shows the minimum, maxmimum and average load modulation over eight ASK transitions. Eight transitions correspond to one bit. This number is defined by the NFC Forum as a quality indicator of the load modulation.
- The right pane shows the minimum, maximum and average load modulation over one ASK transition.

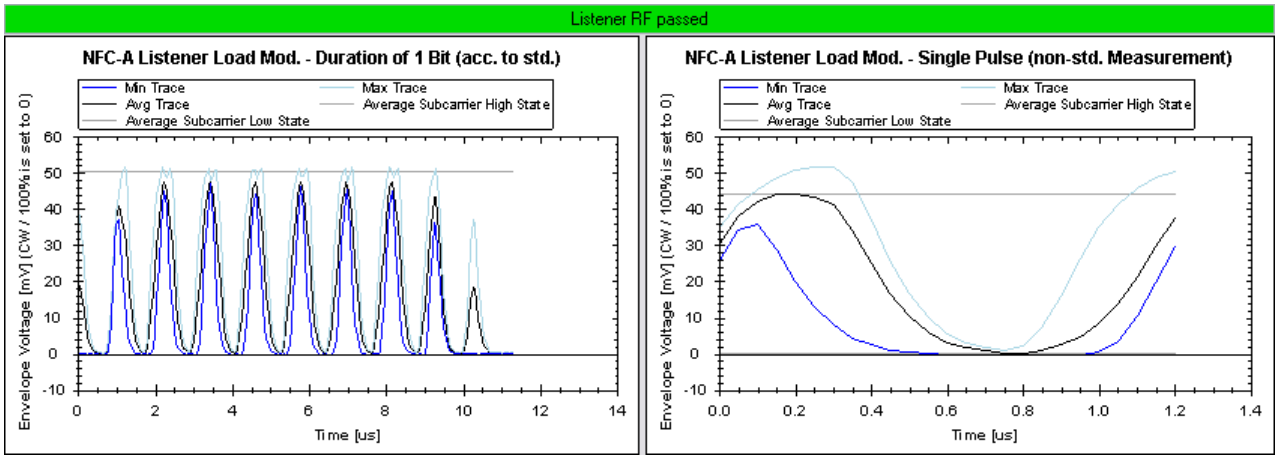


Fig. 3-6: NFC-A listener signal (based on example file NFC-A_Example.iq.tar)

The displayed results are an indicator of the evenness of the ASK transitions. The power levels are displayed in the unit mV. The zero level is normalized to the 100 % of the power level of the carrier signal.

In case of NFC-B, the result display shows one pane. The pane shows the minimum, maximum and average load modulation over all measured ASK transitions.

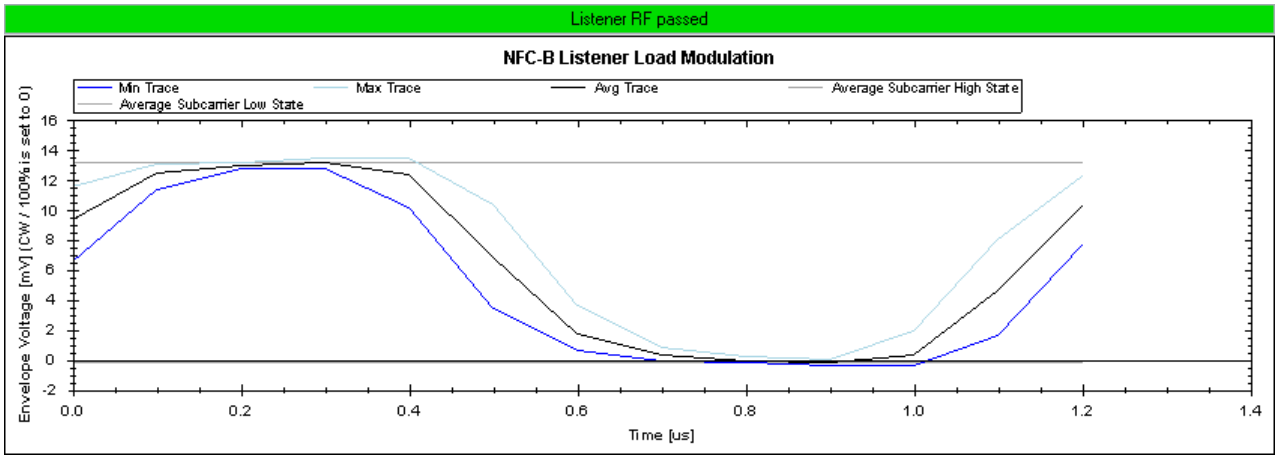


Fig. 3-7: NFC-B listener signal (based on example file NFC-B_Example.iq.tar)

In case of NFC-F, the result display shows two panes.

- The left pane shows the falling edge of the load modulation.
- The right pane shows the rising edge of the load modulation.

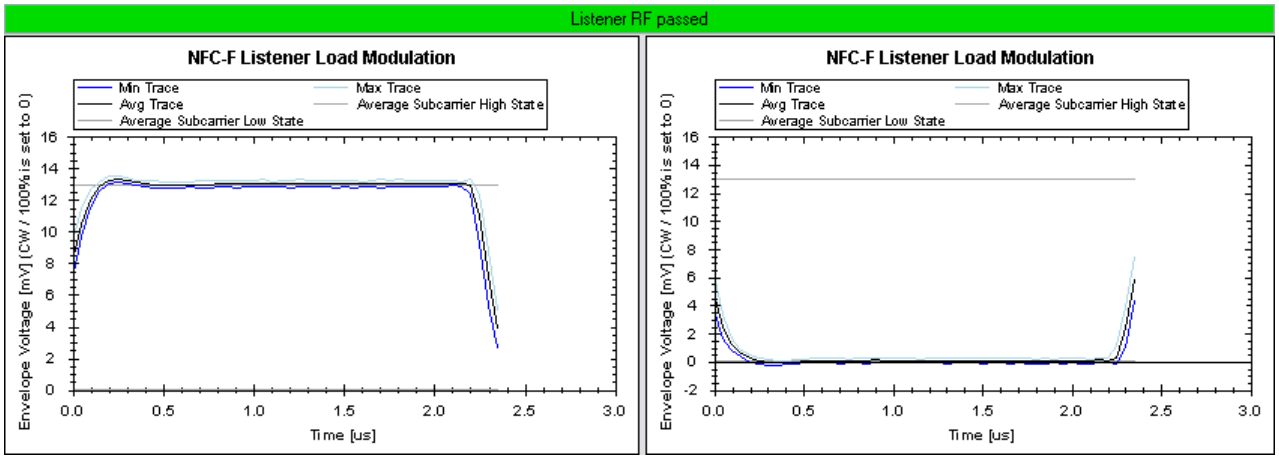


Fig. 3-8: NFC-B listener signal (based on example file NFC-F_424kB_Example.iq.tar)

The listener RF characteristics contain several traces, distinguished by different colors. For a quick assessment of the contents of the result display, it includes a key to the colors above the diagram.

- Grey lines
  The grey lines indicate the lower and upper load modulation levels.
- Blue, black and green traces
  The blue, black and green traces show the RF characteristics of the load modulation. The different colors represent different evaluation methods.
  – The blue trace represents the maximum
  – The light green trace represents the minimum load modulation that occured during the transmission.
  – The black trace represents the average load modulation that occured during the transmission.

The number of load modulation cycles included in the evaluation of the minimum, maximum and average power depends on the number of transmitted bits.

Example:

In case of the signal shown below (from the "Capture Buffer" result display), the software would include 17 load modulation cycles in the evaluation of the minimum, maximum and average traces.

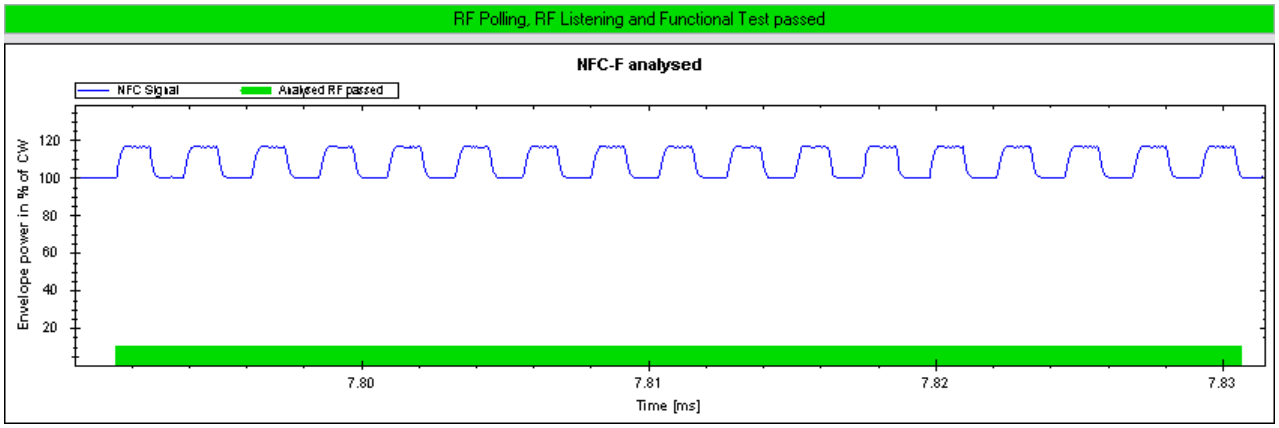


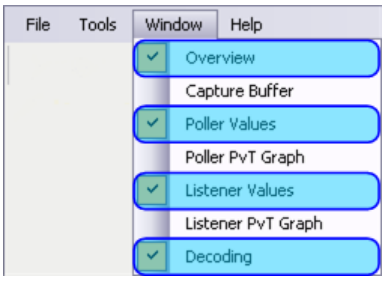
Fig. 3-9: Several NFC-F load modulation cycle (based on example file NFC-F_424kB_Example.iq.tar)

3.2 Numerical Results

The numerical results for NFC measurements show various test results in numerical format.

The software features four numerical result displays, containing different information about the complete RF signal, the NFC poller and the NFC listener.

► Select the "Overview", the"Poller Values", the "Listener Values" or the "Decoding" item from the "Window" menu.



The software opens the corresponding windows and displays the results if already available.

3.2.1 Result Overview

The result overview contains basic characteristics of the signal that has been analyzed.

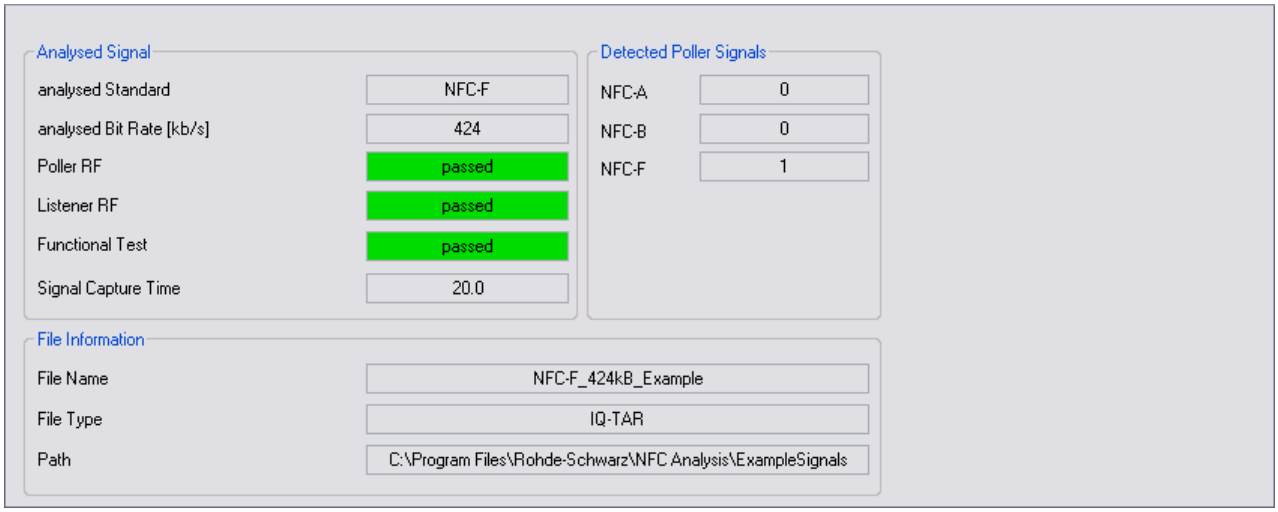


Fig. 3-10: Result overview containing the results for the analysis of an NFC-F signal (based on example file NFC-F_424kB_Example.iq.tar)

Analyzed Signal

The "Analyzed Signal" pane of the "Result Overview" contains various general information about the signal currently analyzed.

The analyzed modulation type and bitrate are the modulation type and bitrate that have been detected. If you have set those two manually, they have to match the actual signal. Otherwise, the software is not able to decode the signal and will show "n/a" for all results.

The pane also contains general pass and fail information of the poller and listener RF characteristics regarding the limits defined by the NFC Forum. If the signal is within the defined limits, the test has "Passed", otherwise it has "Failed". If the result could not be interpreted, the software shows an "Unclear" information.

The Functional Test checks if the communication between poller and listener works alright. Details of the functional test are summarized in the Decoding result display.

The signal capture time is the Capture Length defined on the measurement equipment.

SCPI command:

`FETCh:DEMod:RESult?` on page 54
`FETCh:LISTener:RF:RESult?` on page 55
`FETCh:NFC:STANdard?` on page 56
`FETCh:NFC:BITRate?` on page 55
`FETCh:POLLer:RF:RESult?` on page 56
`FETCh:SWEep:TIME?` on page 56

Detected Poller Signals

The "Detected Poller Signals" pane of the "Result Overview" shows the number of poller signals of each NFC modulation type that has been detected in the recorded I/Q data.

SCPI command:

`FETCh:NFC:ASIGnals?` on page 55
`FETCh:NFC:BSIGnals?` on page 55
`FETCh:NFC:FSIGnals?` on page 55

File Information / Instrument Information
The "File Information" pane of the "Result Overview" shows details of the .iq.tar file in case you analyze a signal from a file. The file information consists of the file name, the file type and the location of the file.

When record I/Q data from measurement equipment, the "Instrument Information" pane is shown instead. It contains the IP address and center frequency of the equipment.

3.2.2 Decoded Signal

The "Decoding" result display shows the details of the functional test.

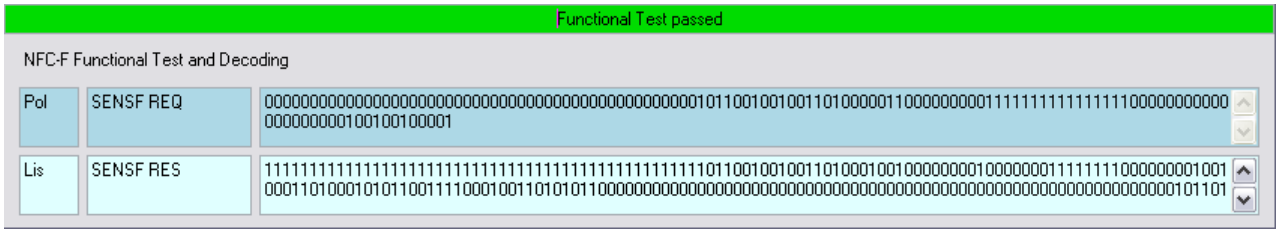


Fig. 3-11: Decoded NFC-F signal (based on example file NFC-F_424kB_Example.iq.tar)

The functional test determines if the communication between NFC devices work. It includes the commands and corresponding bit sequences that have been sent during the transmission of the signal. The result display shows the commands in consecutive order and shows if the command is a command sent by the poller or a command sent by the listener. Poller commands are shown in blue, listener commands in a light shade of blue.

The communication works if the listener sends a response to a poller request as expected. If not, the functional test fails. If the communication contains an unknown command, the functional test will show an "Unclear" message.

SCPI commands:

`[SENSe]:DEMod:BITS?` on page 72

`[SENSe]:DEMod:COMMands?` on page 73

3.2.3 Poller Characteristics

The "Poller Values" result display contains miscellaneous test results for the NFC poller. In addition, it contains an illustration that shows the typical characteristics of an NFC poller low state transition. Note that the shape of the low state transistion for NFC-A signals is different to that of NFC-B and NFC-F signals.

Combining graphical and numerical results
When you display the numerical results, it is best if you do so in combination with the graphical poller test results.

For more information see chapter 3.1.2, "Poller Characteristics", on page 21.

The poller is defined as the device that actively sends the data and provides the power necessary for the data transmission.

The "Poller Values" result display is made up out of several elements and result categories.

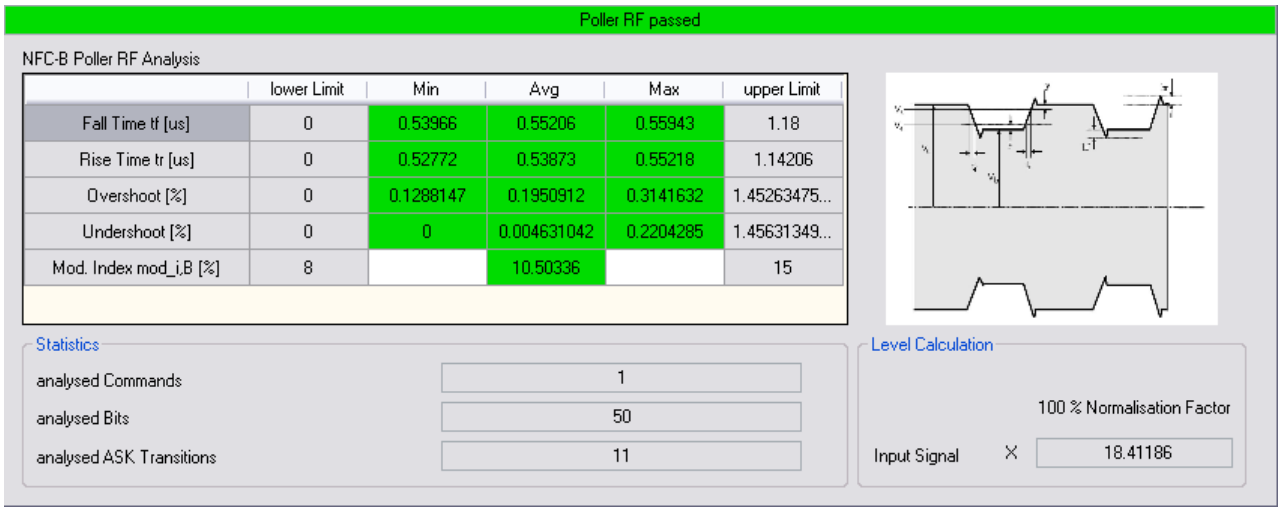


Fig. 3-12: Poller results of an NFC-B signal (based on example file NFC-B_Example.iq.tar)

3.2.3.1 NFC-<x> Poller RF Analysis

The RF analysis contains several results that indicate the signal quality. For most results, the software shows several numbers.

- Lower limit
  Shows the minimum value the result may have and still be compliant to the limits specified by the NFC Forum.
  This number is not a test result, but is taken from the standard.
- Minimum
  Shows the result with the lowest value within the signal section defined for that result.
  The minimum result is determined over all poller signals of the same modulation type in the capture buffer.
- Average
  Shows the average result within the signal section defined for that result.
  The average result is determined over all poller signals of the same modulation type in the capture buffer.
- Maximum
  Shows the result with the highest value within the signal section defined for that result.
  The maximum result is determined over all poller signals of the same modulation type in the capture buffer.
- Upper limit

Shows the maximum value the result may have and still be compliant to the limits specified by the NFC Forum.
This number is not a test result, but is taken from the standard.

The contents depend on the NFC standard. The main difference are the timing results.

In case of the NFC-A modulation type, the low state transition is split into several sections, each with a different, but fix, length.

	lower Limit	Min	Avg	Max	upper Limit
t1 [us]	2.06	2.40507	2.41401	2.45834	2.99
t2 [us]	0.52	1.0756	1.08268	1.09013	2.41401
t3 [us]	0.41806501...	0.53938	0.54313	0.54493	1.18
t4 [us]	0	0.27538	0.27871	0.27974	0.44
t5 [us]	0	0.0	0.0	0.0	0.5
Overshoot Vo,A [%]	0	0.07106781	0.2132416	0.447998	7.69860169...
Undershoot Vu,A [%]	0	1.410356	1.471236	1.653141	7.69860169...
ASK Mod. Depth [%]	95		98.01471		100

Fig. 3-13: Poller RF analysis table for NFC-B and -F signals (based on example file NFC-A_Example.iq.tar)

In case of the NFC-B and NFC-F modulation type, only the length of the rising and falling flanks need to be evaluated.

	lower Limit	Min	Avg	Max	upper Limit
Fall Time tf [us]	0	0.34822	0.36365	0.37898	1.18
Rise Time tr [us]	0	0.34123	0.35934	0.37302	0.95364999...
Overshoot [%]	0	0	0.1788635	0.524765	3.36977492...
Undershoot [%]	0	0	0.04152679	0.2935028	3.38375212...
Mod. Index mod_i,F [%]	8		10.48813		15

Fig. 3-14: Poller RF analysis table for NFC-A signals (based on example file NFC-A_Example.iq.tar)

If the signal is within the limits defined by the NFC Forum, the minimum, average or maximum value that has been measured is highlighted in green. If one of the measured values violates the specified limits, it is highlighted in red.

Note that for the modulation index (NFC-B and NFC-F only), the software evaluates a single result only and shows it in the "Average" column.

Timing results for NFC-A

Each of the five timing results (t_1 to t_5) evaluates if a particular section of the signal is within the limits that are defined by NFC Forum. The corresponding sections of t_1 to t_5 as defined in the standard are shown in the illustration next to the results.

SCPI command:

`FETCh:POLLer:TFIVe?` on page 62

`FETCh:POLLer:TFIVe:LIMit?` on page 63

`FETCh:POLLer:TFIVe:RESult?` on page 63

Timing results for NFC-B and NFC-F
Each of the two timing results (t_f and t_r) evaluates if the rising or falling slope of the signal is within the limits that are defined by the NFC Forum. The exact definitions of t_f and t_r are a function of the voltage (V_A and V_B). They are shown in the illustration next to the results.

SCPI command:
`FETCh:POLLer:FTIMe?` on page 64
`FETCh:POLLer:FTIMe:LIMit?` on page 65
`FETCh:POLLer:FTIMe:RESult?` on page 65
`FETCh:POLLer:RTIMe?` on page 65
`FETCh:POLLer:RTIMe:LIMit?` on page 66
`FETCh:POLLer:RTIMe:RESult?` on page 66

Over- and undershoot results
The over- and undershoot results evaluate if the overshoot and undershoot of the signal is within the limits that are defined by the NFC Forum. The over- and undershoot are a percentage of the initial voltage of the carrier signal.

In case of NFC-B and NFC-F the undershoot and overshoot are shown in the illustration as hr and hf.

SCPI command:
`FETCh:POLLer:OSHoot?` on page 59
`FETCh:POLLer:OSHoot:LIMit?` on page 60
`FETCh:POLLer:OSHoot:RESult?` on page 60
`FETCh:POLLer:USHoot?` on page 61
`FETCh:POLLer:USHoot:LIMit?` on page 61
`FETCh:POLLer:USHoot:RESult?` on page 62

ASK Modulation Depth (NFC-A only)
The modulation depth is a result that indicates the magnitude of the voltage drop during the low state transition. The modulation depth is a percentage with 100% voltage representing the voltage of the carrier signal (V_1).

SCPI command:
`FETCh:POLLer:ASKMod?` on page 57
`FETCh:POLLer:ASKMod:LIMit?` on page 58
`FETCh:POLLer:ASKMod:RESult?` on page 58

Modulation Index [mod_i.F.] (NFC-B and -F only)
The modulation index also represents the power drop during the low state transitions, but is a ratio of voltages at defined locations of the low state transition.

$$m_i = \frac{V_a - V_b}{V_a + V_b}$$

with V_a being the high amplitude and V_b being the low amplitude.

SCPI command:
see commands at "ASK Modulation Depth (NFC-A only)" on page 31.

3.2.3.2 Poller Statistics

The statistics section contains statistics about the poller signal.

- Analyzed commands
  Number of commands that have been sent during the transmission of the recorded signal.
- Analyzed bits
  Number of bits that have been transmitted in the recorded signal.
- Analyzed ASK transitions
  Number of low state transitions that could be found in the recorded signal.

SCPI commands:

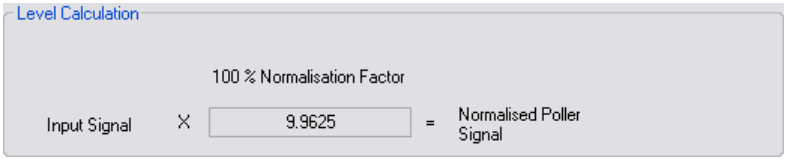
`FETCh:POLLer:NCOMmands?` on page 59

`FETCh:POLLer:NBITs?` on page 58

`FETCh:POLLer:NTRansitions?` on page 59

3.2.3.3 Level Calculation

The level calculation shows the factor that has been used to normalize the voltage of the carrier signal to 100 %.



Example:

If the voltage of the carrier signal is 2 V, a normalization factor of 0.5 is required to normalize the signal to a 100 %.

2 V * 0.5 = 1 = 100 %

3.2.4 Listener Characteristics

The "Listener Values" result display contains miscellaneous test results for the NFC listener. In addition, it contains an illustration that shows the characteristics of the load modulation used to transmit an NFC signal. Note that the illustration for NFC-A signals is different to that of NFC-B and NFC-F signals.

Combining graphical and numerical results

When you display the numerical results, it is best if you do so in combination with the graphical poller test results.

For more information see chapter 3.1.2, "Poller Characteristics", on page 21.

Typically, the listener is defined as the device that passively receives the data. In case of a passive listener, the poller provides the power necessary for the transmission.

The "Listener Values" result display is made up out of several elements and result categories.

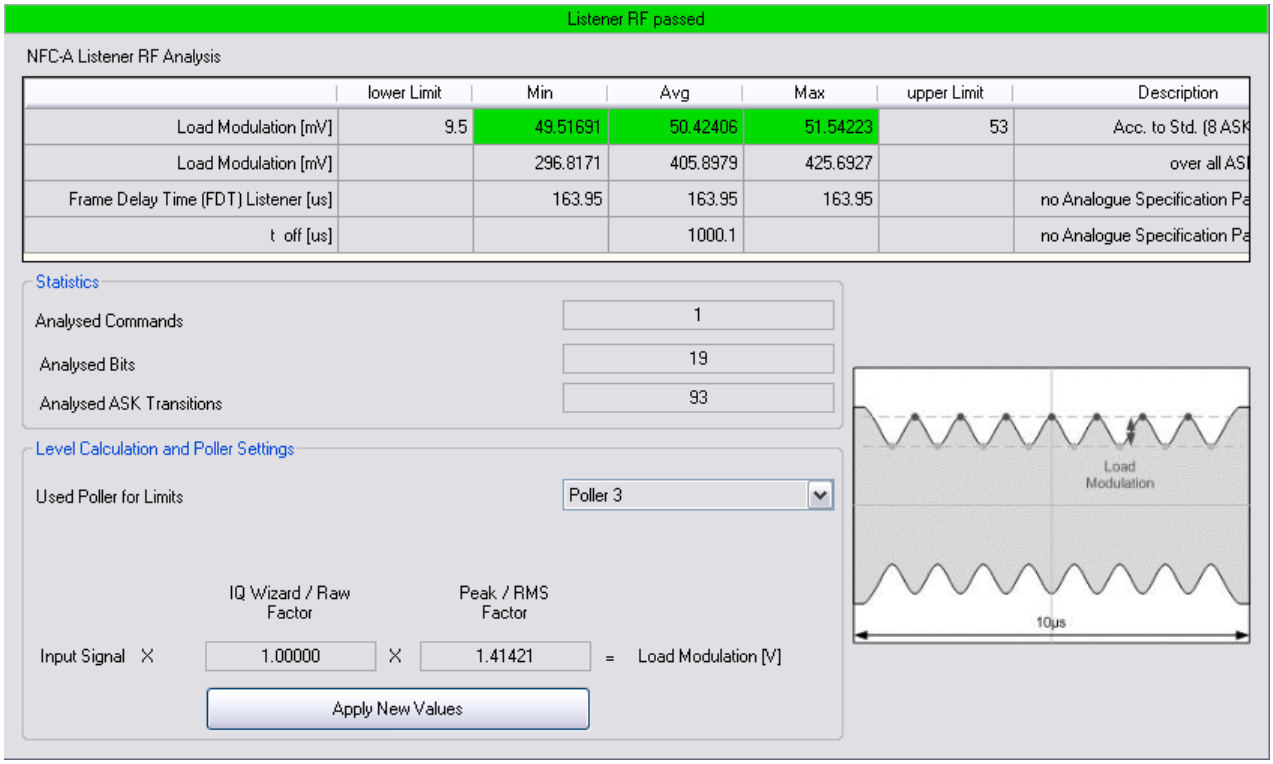


Fig. 3-15: Listener results of an NFC-A signal (based on example file NFC-A_Example.iq.tar)

3.2.4.1 NFC-<x> Listener RF Analysis

The RF analysis contains several results that indicate the signal quality. For each result, the software shows several numbers.

- Lower limit
  Shows the minimum value the result may have and still be compliant to the standard specification.
  This number is not a test result, but is taken from the standard.
- Minimum

Shows the result with the lowest value within the signal section defined for that result. The minimum result is determined over all listener signals of the same modulation type in the capture buffer.

- Average
  Shows the average result within the signal section defined for that result.
  The average result is determined over all listener signals of the same modulation type in the capture buffer.
- Maximum
  Shows the result with the highest value within the signal section defined for that result. The maximum result is determined over all listener signals of the same modulation type in the capture buffer.
- Upper limit
  Shows the maximum value the result may have and still be compliant to the standard specification.
  This number is not a test result, but is taken from the standard.

	lower Limit	Min	Avg	Max	upper Limit	Description
Load Modulation [mV]	9.5	49.51691	50.42406	51.54223	53	Acc. to Std. (8 ASK Transitions)
Load Modulation [mV]		296.8171	405.8979	425.6927		over all ASK Transitions
Frame Delay Time (FDT) Listener [us]		163.95	163.95	163.95		no Analogue Specification Parameter (RF)
t off [us]			1000.1			no Analogue Specification Parameter (RF)

Fig. 3-16: Listener RF analysis table for NFC-A signals (based on example file NFC-A_Example.iq.tar); the contents of NFC-B and NFC-F are a subset of the parameters shown for NFC-A

If the signal is within the limits defined by the NFC Forum, the minimum, average or maximum value that has been measured is highlighted in green. If one of the measured values violates the specified limits, it is highlighted in red.

Note that limits are defined only for the load modulation.

Load Modulation

The two load modulation results evaluate the load which attenuates the electromagnetic field.

NFC-A

For NFC-A, the load modulation limits are defined for one bit which consists of 8 ASK transitions.

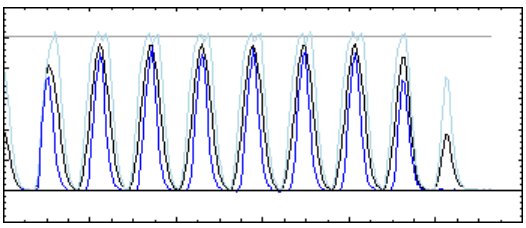


Fig. 3-17: 8 ASK transitions in a NFC-A signal, corresponding to 1 bit

The software shows these as well as the load modulation over all ASK transitions in the signal. The result over all transitions is not measured against limits, because no limits have been defined by the NFC Forum for that case.

NFC-B

For NFC-B and -F limits are defined for one ASK transition. Thus, the software only shows the minimum, maxmimum and average load modulation of all ASK transitions that have been analyzed.

Note that the limit values are different, depending on the poller you are using. For more information see chapter 3.2.4.3, "Level Calculation and Poller Settings", on page 36.

For more information on load modulation see chapter 3.1.3, "Listener Characteristics", on page 23.

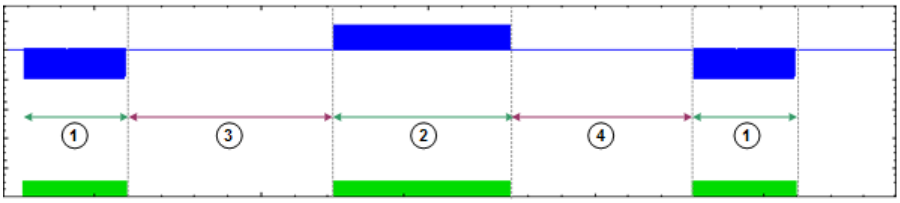
SCPI command:

`FETCh:LISTener:LMALl?` on page 68
`FETCh:LISTener:LMEight?` on page 69
`FETCh:LISTener:LMEight:LIMit?` on page 69
`FETCh:LISTener:LMEight:RESult?` on page 69

Frame Delay Time Listener / Poller

The frame delay time is the time that goes by between a poller request and subsequent communication (response or recurring request) or vice versa.

The time between a poller request and the listener response is called "Frame Delay Time Listener". The time between the listener reponse and a subsequent communication is called "Frame Delay Time Poller".



1 = Poller burst
2 = Listener burst
3 = Frame delay time listener
4 = Frame delay time poller

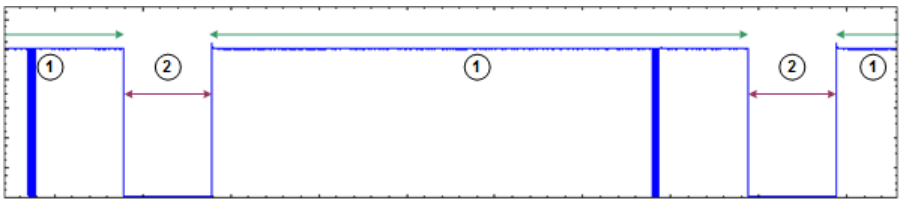
Note that the NFC Forum defines no limits for the frame delay time.

SCPI command:

`FETCh:LISTener:FDTL?` on page 67
`FETCh:LISTener:FDTP?` on page 68

Timing Offset

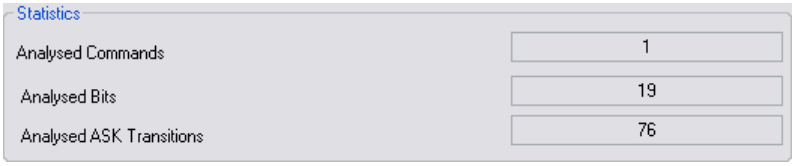
The timing offset is the time between two bursts.



1 = Transmission (on time)
2 = Timing offset (off time)

3.2.4.2 Listener Statistics

The statistics section contains statistics about the listener signal.



- Analyzed commands
  Number of commands that have been sent during the transmission of the recorded signal.
- Analyzed bits
  Number of bits that have been transmitted in the recorded signal.
- Analyzed ASK transitions
  Number of ASK transitions that could be found in the recorded signal.

SCPI commands:

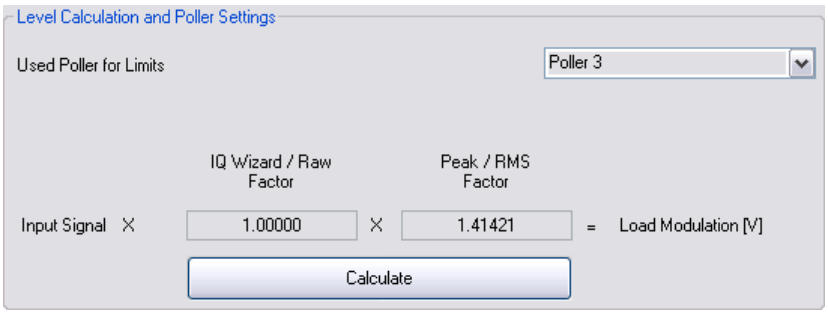
`FETCh:LISTener:NBITs?` on page 70

`FETCh:LISTener:NCOMmands?` on page 70

`FETCh:LISTener:NTRansitions?` on page 70

3.2.4.3 Level Calculation and Poller Settings

The I/Q data that the software analyzes is recorded as RMS values. However, load modulation is not calculated as an RMS value. Therefore, the input signal has to be normalized by a factor of root 2 to get the load modulation result.



SCPI command:

`[SENSe]:LISTener:RAWFactor` on page 71

`[SENSe]:LISTener:RMSFactor` on page 72

Poller settings

The NFC Forum defines three different poller reference antennas with different characteristics. The used poller changes the limits of the load modulation as defined by the NFC Forum.

SCPI command:

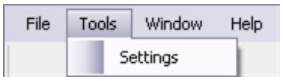
[SENSe]:LISTener:UPFL on page 72

4 Configuration

The R&S FS-K112PC provides several tools and ways to configure an NFC test setup.

- chapter 4.1, "Managing Measurement Configurations", on page 38 (via the menu bar)
- chapter 4.2, "Selecting the NFC Modulation Type", on page 39 (via the toolbar)
- chapter 4.3, "Configuring the Measurement Equipment", on page 40 (via the "Settings" dialog)
- chapter 4.4, "Triggering Measurements", on page 42 (via the "Settings" dialog)
- chapter 4.5, "Defining Diagram Properties", on page 43 (via the "Settings" dialog)

► Select the "Settings" menu item from the "Tools" menu.



The software opens the "Settings" dialog box.
For an overview of the contents, see the corresponding topics below.

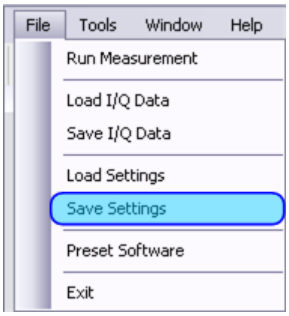
Note that you have to confirm any changes you have made in the dialog box by pressing the "OK" button. If you have entered an invalid value, the software gives a corresponding message.

4.1 Managing Measurement Configurations

The R&S FS-K112PC provides functionality to save and restore a measurement configuration. Saving a configuration is an easy way if a particular configuration is necessary more than once.

Saving measurement configurations

► Select the "Save Settings" menu item from the "Settings" menu.

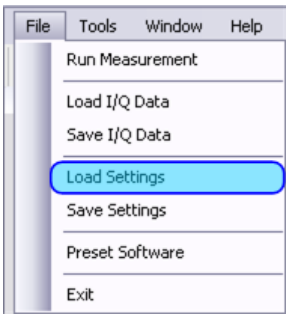


The software opens a dialog box to save the current measurement configuration in a file with the *.nfcset file extension.
SCPI command:

MMEMory:NFC:STORe:SETTings on page 53

Restoring measurement configurations

► Select the "Recall Settings" menu item from the "Settings" menu.



The software opens a dialog box to select a file in the *.nfcset format that contains a previously saved measurement configuration.
SCPI command:
MMEMory:NFC:LOAD:SETTings on page 52

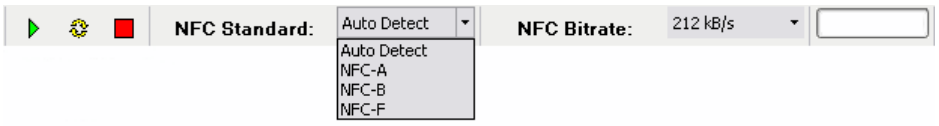
4.2 Selecting the NFC Modulation Type

The NFC Forum defines three near field communication modulation standards: NFC-A, NFC-B and NFC-F. Each modulation type supports one or more bitrates also defined by the NFC Forum. The R&S FS-K112PC supports measurement on all three modulation types and all available bitrates.

Selecting the modulation type

By default, the software automatically detects the modulation type and its bitrate. In case of automatic detection, the software analyzes the first modulation type it can find in the current capture buffer. If you know the modulation type and bitrate you want to test or want to test a particular modulation type (that is not necessarily the first one) in a multi-modulation type signal, you can also select the modulation type and bitrate manually.

► In the toolbar, select the modulation type from the "NFC Standard" dropdown menu.



SCPI command:
CONFigure:NFC:STANdard on page 75

Selecting the bitrate

► In the toolbar, select the bitrate from the "NFC Bitrate" dropdown menu.

Note that the available bitrates (or transmission speeds) depend on the modulation type you have selected:

- NFC-A supports 106 kbit/s
- NFC-B supports 106 kbit/s
- NFC-F supports 212 and 424 kbit/s

SCPI command:

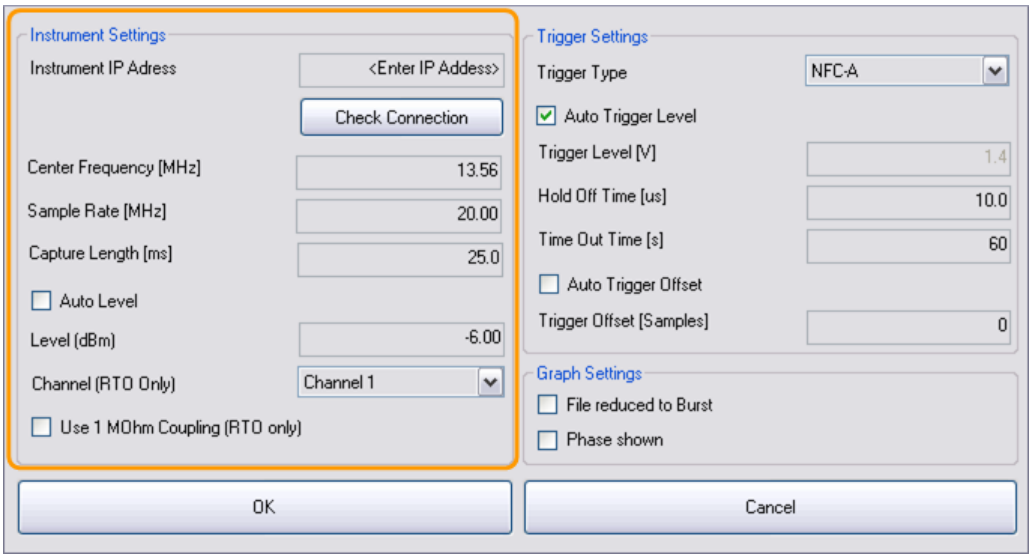
`CONFigure:NFC:BITRate` on page 75

4.3 Configuring the Measurement Equipment

If you are recording signals with an analyzer or oscilloscope, you need to set up and establish a connection. You also have to define the basic signal or measurement characteristics in order to get valid results.

The measurement instrument is either a Rohde & Schwarz spectrum analyzer or oscilloscope. For a list of supported measurement equipment see chapter 2.5, "Connecting the Software to an Instrument", on page 15.

All necessary settings are part of the "Settings" dialog box.



Instrument IP Address
Defines the IP address of the instrument.

If you don't know the IP address of the analyzer, you can figure it out on the analyzer itself. For more information see chapter 2.5, "Connecting the Software to an Instrument", on page 15.

If you are not sure if the IP address you have entered is the right one, you can check if the connection was successful with the "Check Connection" button.

SCPI command:
`CONFigure:ADDRess<instid>` on page 74

Center Frequency
Defines the frequency of the NFC signal in MHz.

The frequency corresponds to the center frequency the measurement equipment is tuned to. For measurements on a signal compliant to the NFC standard, the frequency is usually 13.56 MHz.

SCPI command:
`[SENSe]:FREQuency:CENTer` on page 73

Sample Rate
Defines the sample rate in MHz used used during signal processing.

To get valid measurement results, a sample rate of at least 10 MHz is recommended.

SCPI command:
`TRACe:IQ:SRATe` on page 76

Capture Length
Defines the amount of data to be captured.

The capture length corresponds to the number of samples that the measurement equipment captures during the measurements. Make sure that all NFC commands you want to analyze are captured completely.

SCPI command:
`[SENSe]:SWEep:SAMPles` on page 53

(Auto) Level
Defines the expected power level of the NFC signal at the RF input.

The expected level corresponds to the reference level of the measurement equipment. You can define the level manually or turn on automatic detection of the signal level. If you select automatic detection of the level, the software performs a test measurement that determines the signal power. Based on this measurement, the software subsequently sets the ideal reference level for the measurement.

SCPI command:
`CONFigure:POWer:AUTO` on page 76
`DISPlay:TRACe:Y:RLEV` on page 76

Channel (RTO only)
Selects the channel number the signal is applied to.

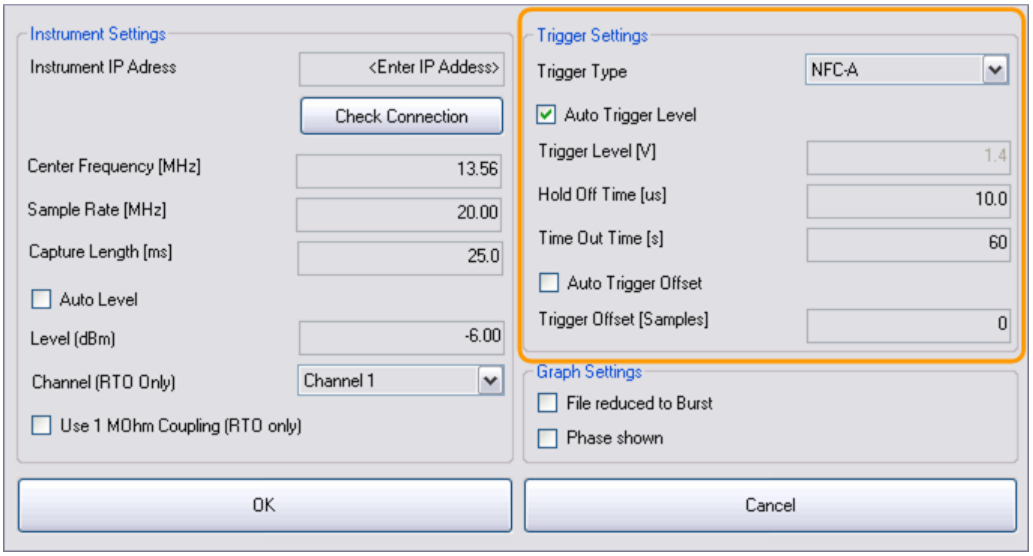
Channel selection is available for measurements with an oscilloscope. The number of channels you can select from depends on the hardware configuration of the oscilloscope.

SCPI command:
`CONFigure:CHANnel` on page 75

4.4 Triggering Measurements

The NFC Measurement Software supports several trigger types or sources and the appropriate trigger settings.

All necessary settings are part of the "Settings" dialog box.



Trigger Type
Selects the trigger source.

Using a trigger initiates a measurement only under certain circumstances (the trigger event). After the trigger event has happened, the analyzer measures until the required amount of data has been captured. The software supports the use of several trigger sources or types.

- Free Run
  Free Run mode is basically a measurement without a trigger. The measurement instrument captures data regardless of the I/Q data contents.
- External
  Starts the measurement when the signal meets or exceeds a particular power level at the external trigger input of the equipment.
- IF Power (spectrum analyzer only)

Starts the measurement when the IF power meets or exceeds a particular power level at the IF stage of the signal processing.

- NFC Trigger (RTO only)
  Starts the measurement on a poller request. Because the poller request of each modulation type has its own characteristic shape, the software provides a customized trigger for each modulation type and bitrate.

SCPI command:
`TRIGger:MODE` on page 77

Trigger Characteristics
In addition to the trigger source, you can define several trigger characteristics.

The **trigger level** defines the voltage that the signal must meet or exceed in order to initiate a measurement. For the NFC trigger, the software supports the automatic definition of the trigger level. In that case, the trigger level is selected according to the typical level of the NFC signal.

The **trigger hold off time** defines a time period that has to pass between one trigger event and the next. If the trigger event happens before this hold off time is over, it does not initiate a new measurement.

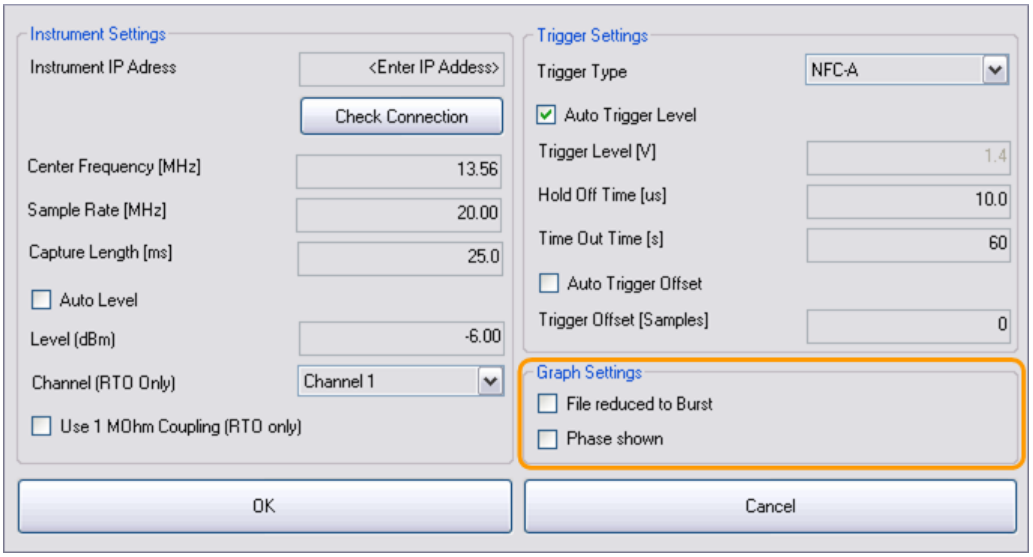
The **time out time** defines the time that the trigger is armed. If the software detects no signal within the time out period, it aborts the measurement.

The **trigger offset** (or delay) is the time that should pass between the trigger event and the start of the measurement. The trigger offset is defined as a particular number of samples. An automatic trigger offset makes sure that the signal itself is at the beginning of the capture buffer.

SCPI command:
Trigger level:
`TRIGger:LEVel:AUTO` on page 77
`TRIGger:LEVel[:VALue]` on page 77
Holdoff time:
`TRIGger:HOLDoff[:VALue]` on page 77
Time out time:
Trigger offset:
`TRIGger:OFFSet:AUTO` on page 78
`TRIGger:OFFSet[:VALue]` on page 78

4.5 Defining Diagram Properties

All necessary settings are part of the "Settings dialog box."



File Reduced To Burst
Turns a reduction of the recorded signal on and off.

If on, the software analyzes only those parts of the recorded signal that it detects as a burst according to one of the modulation types. The rest of the data is dismissed. Reducing the data to the bursts increases the speed of the measurement.

SCPI command:
`[SENSe]:NFC:FRTBurst` on page 74

Phase Shown
Turns the display of the phase characteristics of the signal on and off.

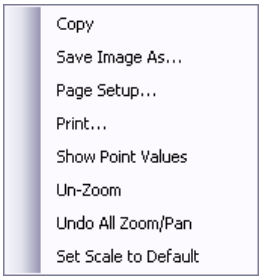
SCPI command:
`[SENSe]:NFC:PSHown` on page 74

5 Analysis

The NFC analysis software provides several tools to get more detailed information on the measurement results. The corresponding tools are part of the context menu.

► Click anywhere within the diagram area of one of the result displays with the right mouse button.

The context menu opens.



Taking a screenshot of the results

The software allows you to save a copy of the result display to the computer clipboard. Alternatively, you can directly save an image of the result display to an internal or external storage device in various image formats like emf, png or jpg.

► Select the "Copy" or "Save Image As..." menu item from the context menu.
When you copy the results, the software moves the screenshot to the clipboard.
When you save the image, the software opens a dialog box to define a name and file format for the screenshot.

Printing the results

The software allows you to send a copy of the result display to any of the printers you have installed on your computer.

Before you print the results, you can configure the printer page setup.

► Select the "Page Setup..." menu item from the context menu.

The software opens a dialog box to define the page layout

► Select the "Print..." menu item from the context menu.

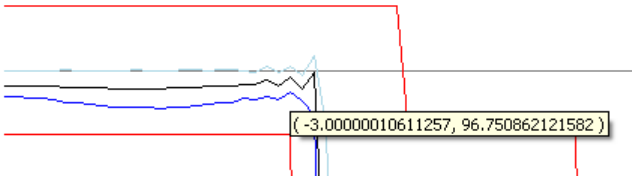
The software sends the copy of the result display to the selected printing device.

Displaying numeric results in the diagram

If you want to see the exact results or values at a particular point of one of the traces, you can turn on the display of coordinates when you move the mouse over a line or trace.

Note that this works only in places of the diagram where it is occupied by a line or trace.

► Select the "Show Point Values" menu item from the context menu.



Zooming into the diagram

If you want to see parts of the diagram area in more detail, you can use the zoom.

► Mark the area by keeping the mouse button pressed and moving the cursor over the area you need to see in more detail.
You can zoom in as far as you want. The R&S FS-K112PC adjusts the scale and labels of the horizontal and vertical axis accordingly.

► To zoom out again, select "Unzoom" from the context menu.

Note that if you use "Unzoom", the software only zooms back to the last magnification stage. So if you used the zoom three times, you also have to unzoom three times to return to the original state of the diagram.
To return to the default state, select "Set Scale to Default" from the context menu.

6 Remote Control Commands

The following remote control commands are necessary to use the NFC measurement software.

6.1 Introduction

Commands are program messages that a controller (e.g. a PC) sends to the instrument or software. They operate its functions ('setting commands') and request information ('query commands'). Some commands only work either way (setting only, query only), others work both ways (setting and query).

The syntax of a SCPI command consists of a so-called header and, in most cases, one or more parameters. A query command must append a question mark after the last header element, even if it contains a parameter.

A header contains one or more keywords, separated by a colon. Header and parameters are separated by a "white space" (ASCII code 0 to 9, 11 to 32 decimal, e.g. blank). If there is more than one parameter for a command, these are separated by a comma from one another.

This chapter summarizes the most important characteristics that you need to know when working with SCPI commands. For a more complete description, refer to the manual of one of the R&S analyzers.

Remote command examples

Note that some remote command examples mentioned in this introductory chapter may not be supported by this application.

6.1.1 Long and Short Form

The keywords have a long and a short form. You can use either the long or the short form, but no other abbreviations of the keywords.

The short form is emphasized in upper case letter. Note however, that this emphasis only serves the purpose to distinguish the short from the long form in the manual. For the instrument, the case does not matter.

Example:

`SENSe:FREQuency:CENTer` is the same as `SENS:FREQ:CENT`.

6.1.2 Numeric Suffixes

Some keywords have a numeric suffix if the command can be applied to multiple instances of an object. In that case, the suffix selects a particular instance (e.g. a measurement window).

Numeric suffixes are indicated by angular brackets (<n>) next to the keyword.

If you don't use a suffix for keywords that support one, it is treated as a 1.

Example:

`DISPlay[:WINDow<1...4>]:ZOOM:STATe` enables the zoom in a particular measurement window, selected by the suffix at `WINDow`.

`DISPlay:WINDow4:ZOOM:STATe ON` refers to window 4.

6.1.3 Optional Keywords

Some keywords are optional and are only part of the syntax because of SCPI compliance. You can include them in the header or not.

Note that if an optional keyword has a numeric suffix and you need to use the suffix, you have to include the optional keyword. Otherwise, the suffix is recognized as a 1.

Optional keywords are emphasized with square brackets.

Example:

Without a numeric suffix in the optional keyword:

`[SENSe:]FREQuency:CENTer` is the same as `FREQuency:CENTer`

With a numeric suffix in the optional keyword:

`DISPlay[:WINDow<1...4>]:ZOOM:STATe`

`DISPlay:ZOOM:STATe ON` enables the zoom in window 1 (no suffix).

`DISPlay:WINDow4:ZOOM:STATe ON` enables the zoom in window 4.

6.1.4 | (Vertical Stroke)

A vertical stroke indicates alternatives for a specific keyword. You can use both keywords to the same effect.

Example:

`[SENSe:]BANDwidth|BWIDth[:RESolution]`

In the short form without optional keywords, `BAND 1MHZ` would have the same effect as `BWID 1MHZ`.

6.1.5 SCPI Parameters

Many commands feature one or more parameters.

If a command supports more than one parameter, these are separated by a comma.

Example:

`LAYout:ADD:WINDow Spectrum,LEFT,MTABle`

Parameters may have different forms of values.

6.1.5.1 Numeric Values

Numeric values can be entered in any form, i.e. with sign, decimal point or exponent. In case of physical quantities, you can also add the unit. If the unit is missing, the command uses the basic unit.

Example:

with unit: `SENSe:FREQuency:CENTer 1GHZ`

without unit: `SENSe:FREQuency:CENTer 1E9` would also set a frequency of 1 GHz.

Values exceeding the resolution of the instrument are rounded up or down.

If the number you have entered is not supported (e.g. in case of discrete steps), the command returns an error.

Instead of a number, you can also set numeric values with a text parameter in special cases.

- MIN/MAX
  Defines the minimum or maximum numeric value that is supported.
- DEF
  Defines the default value.
- UP/DOWN
  Increases or decreases the numeric value by one step. The step size depends on the setting. In some cases you can customize the step size with a corresponding command.

Querying numeric values

When you query numeric values, the system returns a number. In case of physical quantities, it applies the basic unit (e.g. Hz in case of frequencies). The number of digits after the decimal point depends on the type of numeric value.

Example:

Setting: `SENSe:FREQuency:CENTer 1GHZ`

Query: `SENSe:FREQuency:CENTer?` would return `1E9`

In some cases, numeric values may be returned as text.

- INF/NINF
  Infinity or negative infinity. Represents the numeric values 9.9E37 or -9.9E37.
- NAN
  Not a number. Represents the numeric value 9.91E37. NAN is returned in case of errors.

6.1.5.2 Boolean

Boolean parameters represent two states. The "ON" state (logically true) is represented by "ON" or a numeric value 1. The "OFF" state (logically untrue) is represented by "OFF" or the numeric value 0.

Querying boolean parameters

When you query boolean parameters, the system returns either the value 1 ("ON") or the value 0 ("OFF").

Example:

Setting: `DISPlay:WINDow:ZOOM:STATe ON`

Query: `DISPlay:WINDow:ZOOM:STATe?` would return `1`

6.1.5.3 Text

Text parameters follow the syntactic rules of keywords. You can enter text using a short or a long form. For more information see chapter 6.1.1, "Long and Short Form", on page 47.

Querying text parameters

When you query text parameters, the system returns its short form.

Example:

Setting: `SENSe:BANDwidth:RESolution:TYPE NORMal`

Query: `SENSe:BANDwidth:RESolution:TYPE?` would return `NORM`

6.1.5.4 Character Strings

Strings are either text or number. They have to be in straight quotation marks. You can use a single quotation mark - ' - or a double quotation mark - ".

Example:

```
INSTRument:DELete 'Spectrum'
```

6.1.5.5 Block Data

Block data is a format which is suitable for the transmission of large amounts of data.

The ASCII character # introduces the data block. The next number indicates how many of the following digits describe the length of the data block. In the example the 4 following digits indicate the length to be 5168 bytes. The data bytes follow. During the transmission of these data bytes all end or other control signs are ignored until all bytes are transmitted. #0 specifies a data block of indefinite length. The use of the indefinite format requires a NL^END message to terminate the data block. This format is useful when the length of the transmission is not known or if speed or other considerations prevent segmentation of the data into blocks of definite length.

6.2 Measurement Control

The following commands are required to perform and control measurements.

INITiate:REFResh

This command updates the measurement results based on the I/Q data currently in the capture buffer.

Note that the command does not initiate a recording of new I/Q data.

Example: `INIT:REFR`
Updates the measurement results.

Usage: Event

INITiate[:IMMediate]

This command initiates a measurement sequence.

The measurement sequence consists of the recording of I/Q data on the measurement equipment and subsequent analysis of the I/Q data.

Example: `INIT`
Initiates the measurement.

Usage: Event

6.3 General Commands

The following commands are necessary to store and load instrument settings and import and export measurement results.

FORMat[:DATA] [<Format>]

This command selects the data format that is used for transmission of trace data.

Parameters:

<Format>

ASCii
ASCii format, separated by commas.
This format is almost always suitable, regardless of the actual data format. However, the data is not as compact as other formats may be.

REAL,32
32-bit IEEE 754 floating-point numbers in the "definite length block format".

Example: `FORM ASC`
Selects the ASCII format.

MMEMory:NFC:LOAD:IQ <Filename>

This command restores a previously saved I/Q data file.

Setting parameters:

<Filename> Sting containing the file name and path.
The extension of the file is *.iq.tar.

Example:
```
MMEM:NFC:LOAD:IQ 'c:
\signals\iq_nfc_data.iq.tar'
```
Loads the I/Q file `iq_nfc_data.iq.tar` located in the directory `c:\signals\`.

Usage: Setting only

MMEMory:NFC:LOAD:SETTings <Filename>

This command restores a previously saved configuration file.

Setting parameters:

<Filename> String containing the file name and path.
The extension of the file *.nfcset.

Example: `MMEM:NFC:LOAD:SETT 'nfc_settings.nfcset'`
Loads the I/Q data file `nfc_settings.nfcset`.

Usage: Setting only

MMEMory:NFC:STORe:IQ <Filename>

This command saves recorded I/Q data to a file.

Parameters:

<Filename> String containing the file name and path.
The extension of the file is *.iq.tar.

Example: `MMEM:NFC:STOR:IQ 'iq_nfc_data.iq.tar'`
Saves the I/Q data to a the file `iq_nfc_data.iq.tar`.

Usage: Setting only

MMEMory:NFC:STORe:SETTings <Filename>

This command saves the currrent software configuration to a file.

Setting parameters:

<Filename> String containing the file name and path.
The extension of the file is *.nfcset.

Example: `MMEM:NFC:STOR:SETT 'c:\signals\nfc_settings.nfcset'`
Saves the settings to file `c:\signals\nfc_settings.nfcset`.

Usage: Event

[SENSe]:SWEep:SAMPles <Samples>

This command defines the signal capture length.

Parameters:

<Samples> Capture length in samples.

Example: `SWE:SAMP 2000`
Defines a capture length of 2000 samples.

SYSTem:PRESet

This command presets the software.

Example: `SYST:PRES`
Initiates a preset.

Usage: Event

TRACe[:DATA]? <ResultType>

This command queries the I/Q data.

Parameters:

<ResultType> **TRACE1**
Queries the I/Q data shown in the Capture Buffer.

Return values:

<TraceData> List of level values in % of the continuous wave signal.
The amount of values depends on the capture length and sample rate.

Example: `TRAC? TRACE1`
would return, e.g.
`99.6267547607422,100.052139282227,`
`99.947868347168,99.8878326416016,99.8515625,`
`100.108985900879,99.5992965698242,...`

Usage: Query only

6.4 Result Overview

The following commands query general measurement results.

FETCh:DEMod:RESult?

This command queries the result of the functional check as shown in the "Result Overview".

Return values:

<TestResult> **PASS**
The functional test was successful.

FAILED
The functional test was not successful.

UNCLEAR
The functional test result could not be determined.

Example: FETCh:DEM:RES?
would return, e.g.:
PASSED

Usage: Query only

FETCh:LISTener:RF:RESult?

This command queries the result of the listener test as shown in the "Result Overview".

Return values:

<TestResult>

FAILED
Listener test has failed.

PASS
Listener test has passed.

UNSYNC
Software could not synchronize with the signal.

Example: FETC:LIST:RF:RES?
would return, e.g.
FAILED

Usage: Query only

FETCh:NFC:BITRate?

This command queries the NFC bitrate of the signal that has been analyzed.

Return values:

<NFCBitrate>

BR106
The bitrate is 106 kbit/s.

BR212
The bitrate is 212 kbit/s.

BR424
The bitrate is 424 kbit/s.

Example: FETC:NFC:BITR?
would return, e.g.
BR212

Usage: Query only

FETCh:NFC:ASIGnals?
FETCh:NFC:BSIGnals?
FETCh:NFC:FSIGnals?

This command queries the number of poller commands that have been analyzed.

Return values:

<Number> Number of NFC-A, -B and -F poller commands in the I/Q data.
The modulation type is defined by the last syntax element.

Example: FETC:NFC:ASIG?
Queries the number of NFC-A poller commands and would return, e.g.:
2

Usage: Query only

FETCh:NFC:STANdard?

This command queries the NFC modulation type that has been analyzed.

Return values:

<NFCStandard>
NFCA
The signal is based on NFC-A.
NFCB
The signal is based on NFC-B.
NFCF
The signal is based on NFC-F.

Example: FETC:NFC:STAN?
would return, e.g.:
NFCB

Usage: Query only

FETCh:POLLer:RF:RESult?

This command queries the result of the poller test as shown in the "Result Overview".

Return values:

<TestResult>
FAILED
Poller test has failed.
PASS
Poller test has passed.
UNSYNC
Software could not synchronize with the signal.

Example: FETC:POLL:RF:RES?
would return, e.g.:
PASS

Usage: Query only

FETCh:SWEep:TIME?

This command queries the signal capture time.

Return values:

<Time> Signal capture time in ms.

Example: `FETC:SWE:TIME?`
would return, e.g.:
`50`

Usage: Query only

6.5 Querying NFC-A Poller Results

The following commands query the results of NFC-A signals.

FETCh:POLLer:ASKMod?

This command queries the modulation depth (NFC-A) or the modulation index (NFC-B and -F).

Return values:

<ModulationDepth> NFC-A: modulation depth in %.
NFC-B / -F: modulation index in %.

Example: `FETC:POLL:ASKM?`
Queries the modulation depth or index.
Result: `99.9` %

Usage: Query only

FETCh:POLLer:ASKMod:LIMit? <Limit>

This command queries the limits of the ASK modulation depth (NFC-A) or the modulation index (NFC-B and -F).

The limits for the modulation depth and index are defined by the NFC Forum.

Query parameters:

<Limit>
LOWer
Queries the lower limit.
UPPer
Queries the upper limit.

Return values:

<LimitValue> Limit in %.

Example: `FETC:POLL:ASKM:LIM? LOW`
would return, e.g.:
`95`

Usage: Query only

FETCh:POLLer:ASKMod:RESult?

This command queries the limit check result of the modulation depth (NFC-A) or modulation index (NFC-B and NFC-F).

Return values:

<LimitCheck>
PASS
Modulation depth or index within the limits.
FAILED
Modulation depth or index not within the limits.

Example: `FETC:POLL:ASKM:RES?`
would return, e.g.:
`PASS`

Usage: Query only

FETCh:POLLer:NBITs?

This command queries the number of bits that have been transmitted in the recorded signal.

Return values:

<BitNumber> Number of bits.

Example: `FETC:POLL:NBIT?`
would return, e.g.
`128`

Usage: Query only

FETCh:POLLer:NFACtor?

This command queries the normalization factor used for level calculation.

Return values:
<NFactor> Normalization factor without unit.

Example: `FETC:POLL:NFAC?`
would return, e.g.
`9.9625`

Usage: Query only

FETCh:POLLer:NCOMmands?

This command queries the number of commands that have been found during transmission of the recorded signal.

Return values:
<CommandNumber> Number of the commands.

Example: `FETC:POLL:NCOM?`
would return, e.g.:
`1`

Usage: Query only

FETCh:POLLer:NTRansitions?

This command queries the number of low state transitions that have been found in the recorded signal.

Return values:
<Number> Number of low state transitions.

Example: `FETC:POLL:NTR?`
would return, e.g.:
`156`

Usage: Query only

FETCh:POLLer:OSHoot? <ResultType>

This command queries the measurement results for the signal overshoot.

Query parameters:

<ResultType>

AVERage
Queries the average results.

MINimum
Queries the minimum results.

MAXimum
Queries the maximum results.

Return values:

<Overshoot> Signal overshoot in %.

Example: `FETC:POLL:OSH? MIN`
would return, e.g.
`0.0695343`

Usage: Query only

FETCh:POLLer:OSHoot:LIMit? <Limit>

This command queries the limits of the signal overshoot.

The limits for the overshoot are defined in the standard.

Query parameters:

<Limit>

LOWer
Queries the lower limit.

UPPer
Queries the upper limit.

Return values:

<LimitValue> Limit in %.

Example: `FETC:POLL:OSH:LIM? UPP`
would return, e.g.:
`1.5909356`

Usage: Query only

FETCh:POLLer:OSHoot:RESult? <State>

This command queries the limit check result of the signal overshoot.

The limits for the signal overshoot are defined in the standard.

Parameters:

<State>

AVERage
Queries the overshoot limit check result of the average value.

MINimum
Queries the overshoot limit check result of the minimum value.

MAXimum
Queries the overshoot limit check result of the maximum value.

Return values:

<LimitCheck> **PASS**
Signal within the limits.

FAILED
Signal not within the limits.

Example: `FETC:POLL:OSH:RES? MAX`
would return, e.g.:
`PASS`

Usage: Query only

FETCh:POLLer:USHoot? <ResultType>

This command queries the measurement results for the signal undershoot.

Query parameters:

<ResultType> **AVERage**
Queries the average results.

MINimum
Queries the minimum results.

MAXimum
Queries the maximum results.

Return values:

<Undershoot> Signal undershoot in %.

Example: `FETC:POLL:USH MAX?`
would return, e.g.:
`0.5830841`

Usage: Query only

FETCh:POLLer:USHoot:LIMit? <Limit>

This command queries the limits of the signal undershoot.

The limits for the undershoot are defined in the standard.

Query parameters:

<Limit> **LOWer**
Queries the lower limit.

UPPer
Queries the upper limit.

Return values:

<LimitValue> Limit in %.

Example: `FETC:POLL:USH:LIM? LOW`
would return, e.g.:
`1.5457385`

Usage: Query only

FETCh:POLLer:USHoot:RESult? <State>

This command queries the limit check result of the signal undershoot.

The limits for the signal undershoot are defined in the standard.

Parameters:

<State>

AVERage
Queries the undershoot limit check result of the average value.

MINimum
Queries the undershoot limit check result of the minimum value.

MAXimum
Queries the undershoot limit check result of the maximum value.

Return values:

<LimitCheck>

PASS
Signal within the limits.

FAILED
Signal not within the limits.

Example:

```
FETC:POLL:USH:RES MAX?
```

would return, e.g.:

```
PASS
```

Usage: Query only

FETCh:POLLer:TONE?
FETCh:POLLer:TTWO?
FETCh:POLLer:TTHRee?
FETCh:POLLer:TFOur?
FETCh:POLLer:TFIVe? <ResultType>

This command queries the measurement results for the corresponding signal segment t_x.

Query parameters:

<ResultType>

AVERage
Queries the average results.

MINimum
Queries the minimum results.

MAXimum
Queries the maximum results.

Return values:

<Time>

Length of signal segment t_1, t_2, t_3, t_4 or t_5 in ms.

Example:

```
FETC:POLL:TONE MAX?
```

Queries the length of the signal segment t_1.

Result: `2.8` µs

Usage: Query only

FETCh:POLLer:TONE:LIMit?
FETCh:POLLer:TTWO:LIMit?
FETCh:POLLer:TTHRee:LIMit?
FETCh:POLLer:TFOur:LIMit?
FETCh:POLLer:TFIVe:LIMit? <Limit>

This command queries the limits of signal segments t_x.

The limits for the signal segments are defined in the standard.

Query parameters:

<Limit>
LOWer
Queries the lower limit.
UPPer
Queries the upper limit.

Return values:

<LimitValue> Limit of signal segment t_1, t_2, t_3, t_4 or t_5 in ms.

Example:
```
FETC:POLL:TTWO:LIM? UPP
```
would return, e.g.:
```
2.99
```

Usage: Query only

FETCh:POLLer:TONE:RESult?
FETCh:POLLer:TTWO:RESult?
FETCh:POLLer:TTHRee:RESult?
FETCh:POLLer:TFOur:RESult?
FETCh:POLLer:TFIVe:RESult? <State>

This command queries the limit check result of the corresponding signal segment t_x.

Query parameters:

<State>
AVERage
Queries the limit check result of the average value.
MAXimum
Queries the limit check result of the maximum value.
MINimum
Queries the limit check result of the minimum value.

Return values:

<LimitCheck>
PASS
Signal within the limits.
FAILED
Signal not within the limits.

Example:
```
FETC:POLL:TONE:RES? MIN
```
would return, e.g.:
```
FAILED
```

Usage: Query only

6.6 Querying NFC-B and -F Poller Results

The following commands query the results of NFC-B and NFC-F signals.

Commands useful to query NFC-B and NFC-F pollers described elsewhere:

- FETCh:POLLer:ASKMod? on page 57
- FETCh:POLLer:ASKMod:LIMit? on page 58
- FETCh:POLLer:ASKMod:RESult? on page 58
- FETCh:POLLer:NBITs? on page 58
- FETCh:POLLer:NCOMmands? on page 59
- FETCh:POLLer:NFACtor? on page 59
- FETCh:POLLer:NTRansitions? on page 59
- FETCh:POLLer:OSHoot? on page 59
- FETCh:POLLer:OSHoot:LIMit? on page 60
- FETCh:POLLer:OSHoot:RESult? on page 60
- FETCh:POLLer:USHoot? on page 61
- FETCh:POLLer:USHoot:LIMit? on page 61
- FETCh:POLLer:USHoot:RESult? on page 62

Commands exclusive to NFC-B and -F

FETCh:POLLer:FTIMe? <ResultType>

This command queries the measurement results for the signal fall time t_f.

Query parameters:

<ResultType>

AVERage
Queries the average results.

MINimum
Queries the minimum results.

MAXimum
Queries the maximum results.

Return values:

<Time> Fall time in ms.

Example:

```
FETC:POLL:FTIM? MAX
```

would return, e.g.:

```
0.7
```

Usage: Query only

FETCh:POLLer:FTIMe:LIMit? <Limit>

This command queries the limits of signal fall time t_f.

The limits for the fall time are defined in the standard.

Query parameters:

<Limit>
LOWer
Queries the lower limit.
UPPer
Queries the upper limit.

Return values:

<LimitValue> Limit in ms.

Example:
```
FETC:POLL:FTIM:LIM? UPP
```
would return, e.g.:
```
1.18
```

Usage: Query only

FETCh:POLLer:FTIMe:RESult? <State>

This command queries the limit check result of the signal fall time t_f.

The limits for the signal fall time are defined in the standard.

Parameters:

<State>
AVERage
Queries the limit check result of the average signal fall time.
MINimum
Queries the limit check result of the minimum signal fall time.
MAXimum
Queries the limit check result of the maximum signal fall time.

Return values:

<LimitCheck>
PASS
Signal fall time within the limits.
FAILED
Signal fall time not within the limits.

Example:
```
FETC:POLL:FTIM:RES? MAX
```
would return, e.g.:
```
PASS
```

Usage: Query only

FETCh:POLLer:RTIMe? <ResultType>

This command queries the measurement results for the signal rise time t_r.

Query parameters:

<ResultType>

AVERage
Queries the average results.

MINimum
Queries the minimum results.

MAXimum
Queries the maximum results.

Return values:

<Time> Rise time in ms.

Example:
```
FETC:POLL:RTIM? MIN
```
would return, e.g.:
```
0.55
```

Usage: Query only

FETCh:POLLer:RTIMe:LIMit? <Limit>

This command queries the limits of signal rise time.

The limits for the rise time are defined in the standard.

Query parameters:

<Limit>

LOWer
Queries the lower limit.

UPPer
Queries the upper limit.

Return values:

<LimitValue> Limit in ms.

Example:
```
FETC:POLL:RTIM:LIM? LOW
```
would return, e.g.:
```
0.05999999
```

Usage: Query only

FETCh:POLLer:RTIMe:RESult? <State>

This command queries the limit check result of the signal rise time t_r.

The limits for the signal rise time are defined in the standard.

Parameters:

<State>

AVERage
Queries the limit check result of the average signal rise time.

MINimum
Queries the limit check result of the minimum signal rise time.

MAXimum
Queries the limit check result of the maximum signal rise time.

Return values:

<LimitCheck> **PASS**
Signal rise time within the limits.

FAILED
Signal rise time not within the limits.

Example: `FETC:POLL:RTIM:RES? MAX`
would return, e.g.:
`FAILED`

Usage: Query only

6.7 Querying NFC-A Listener Results

The following commands query the results of NFC-A signals.

FETCh:LISTener:FDTL? <ResultType>

This command queries the measurement results for the frame delay time (FDT) of the listening device.

Parameters:

<ResultType> **AVERage**
Queries the average results.

MINimum
Queries the minimum results.

MAXimum
Queries the maximum results.

Return values:

<Time> Frame delay in µs.

Example: `FETC:LIST:FDTL? MAX`
would return, e.g.:
`2424.8`

Usage: Query only

FETCh:LISTener:FDTP? <ResultType>

This command queries the measurement results of the frame delay time (FDT) of the poller.

Parameters:

<ResultType>

AVERage
Queries the average results.

MINimum
Queries the minimum results.

MAXimum
Queries the maximum results.

Return values:

<Time> Frame delay in µs.

Example:
```
FETC:LIST:FDTP? MAX
```
would return, e.g.:
```
533.9
```

Usage: Query only

FETCh:LISTener:LMALI? <ResultType>

This command queries the measurement results of the load modulation over all ASK transitions.

Parameters:

<ResultType>

Note that the parameters only have an effect for NFC-A signals. NFC-B and -F analysis does not calculate minimum and maximum values.

AVERage
Queries the average results.

MINimum
Queries the minimum results.

MAXimum
Queries the maximum results.

Return values:

<Result> Load modulation in mV.

Example:
```
FETC:LIST:LMAL?
```
Queries the (average) load modulation over all transitions for NFC-B and -F signals.
would return, e.g.:
```
20.6
```

Usage: Query only

FETCh:LISTener:LMEight? <ResultType>

This command queries the measurement results of the load modulation over eight low state transistions.

Parameters:

<ResultType>

AVERage
Queries the average results.

MINimum
Queries the minimum results.

MAXimum
Queries the maximum results.

Return values:

<Result> Load modulation in mV.

Example:
```
FETC:LIST:LME? MIN
```
would return, e.g.:
```
20.5
```

Usage: Query only

FETCh:LISTener:LMEight:LIMit? <Limit>

This command queries the limits of the load modulation over eight low state transitions.

The limits for the load modulation are defined in the standard.

Query parameters:

<Limit>

LOWer
Queries the lower limit.

UPPer
Queries the upper limit.

Return values:

<LimitValue> Limit in mV.

Example:
```
FETC:LIST:LME:LIM? UPP
```
would return, e.g.:
```
58
```

Usage: Query only

FETCh:LISTener:LMEight:RESult? <State>

This command queries the limit check result of the load modulation.

Parameters:

<State>

AVERage
Queries the limit check result of the average value.

MINimum
Queries the limit check result of the minimum value.

MAXimum
Queries the limit check result of the maximum value.

Return values:

<LimitCheck>

PASS
Load modulation within the limits.

FAILED
Load modulaiton not within the limits.

Example: `FETC:LIST:LME:RES? MIN`
would return, e.g.
`PASS`

Usage: Query only

FETCh:LISTener:NBITs?

This command queries the number of bits that have been transmitted in the recorded signal.

Return values:

<BitNumber> Number of bits you have queried.

Example: `FETC:LIST:NBIT?`
Queries the analysed bits.

Usage: Query only

FETCh:LISTener:NCOMmands?

This command queries the number of commands that have been sent during transmission of the recorded signal.

Return values:

<CommandNumber> Number of the commands you have queried.

Example: `FETC:LIST:NCOM?`
Queries the analysed commands.

Usage: Query only

FETCh:LISTener:NTRansitions?

This command queries the number of ASK transitions that could be found in the recorded signal.

Return values:

<Number> Number of transitions you have queried.

Example: `FETC:LIST:NTR?`
Queries the analysed transitions.

Usage: Query only

6.8 Querying NFC-B and -F Listener Results

The following commands query the results of NFC-A signals.

Commands useful to query NFC-B and -F listener results described elsewhere:

- `FETCh:LISTener:FDTL?` on page 67
- `FETCh:LISTener:LMALl?` on page 68
- `FETCh:LISTener:NBITs?` on page 70
- `FETCh:LISTener:NCOMmands?` on page 70
- `FETCh:LISTener:NTRansitions?` on page 70

FETCh:LISTener:LMALI:LIMit? <Limit>

This command queries the limits of the load modulation over all low state transitions.

Limits over all low state transitions are not defined in the standard.

Query parameters:

<Limit>
LOWer
Queries the lower limit.
UPPer
Queries the upper limit.

Return values:

<LimitValue> Limit in mV.

Example: `FETC:LIST:LMAL:LIM? LOW`
would return, e.g.:
`9.5`

Usage: Query only

6.9 Configuring Listener Characteristics

[SENSe]:LISTener:RAWFactor <RAWFactor>

This command defines the I/Q Wizard (or raw factor) for level calculation.

Parameters:
<RAWFactor>

Example: `LIST:RAWF 1.1`
Defines a raw factor of 1.1.

[SENSe]:LISTener:RMSFactor <RMSFactor>

This command defines the Peak / RMS factor for level calculation.

Parameters:
<RMSFactor>

Example: `LIST:RMSF 1.41241`
Defines an RMS factor of 1.41241.

[SENSe]:LISTener:UPFL <Signal>

This command selects the poller type.

The poller type changes the limits for the load modulation.

Parameters:
<Signal> P0 | P3 | P6

P0
Selects poller P0.

P3
Selects poller P3.

P6
Selects poller P6.

Example: `LIST:UPFL P6`
Selects poller type P6.

6.10 Signal Decoding

The following commands query the decoding results.

[SENSe]:DEMod:BITS?

This command queries the bit sequences that have been found for the poller and listener.

Return values:
<Bits> List of poller and listener bit sequences, separated by commas. The command first returns the poller bit sequences in consecutive order, then the listener bit sequences in consecutive order.

Example: DEM:BITS?
would return, e.g.
00111010,01101100100011010100,
1010000111101000001

Usage: Query only

[SENSe]:DEMod:COMMands?

This command queries the command syntax of the commands that have been found for poller and listener.

Return values:

<Commands> List of poller and listener commands, separated by commas. The command first returns the poller commands in consecutive order, then the listener commands in consecutive order.

Example: DEM:COMM?
would returnd, e.g.:
SENS REQ,SDD REQ CL1,SENS RES

Usage: Query only

6.11 Configuration

[SENSe]:FREQuency:CENTer <Centerfrequency>

This command defines the frequency of the signal and the frequency the measurement instrument is tuned to.

Parameters:

<Centerfrequency> Frequency in Hz.

Range: 13 MHz to 14 MHz
*RST: 13.56 MHz

Example: `FREQ:CENT 13.6MHZ`
Defines a frequency of 13.6 MHz.

[SENSe]:NFC:FRTBurst <State>

This command turns a reduction of the I/Q data to include the first burst only on and off.

Parameters:

<State> ON | OFF

*RST: OFF

Example: `NFC:FRTB ON`
Reduces the file to a burst.

[SENSe]:NFC:PSHown <State>

This command turns the display of phase characteristics on and off.

Parameters:

<State> ON | OFF

*RST: OFF

Example: `NFC:PSH ON`
Turns the display of phase characteristics on and off.

[SENSe]:SWEep:SAMPles <Samples>

This command defines the signal capture length.

Parameters:

<Samples> Capture length in samples.

Example: `SWE:SAMP 2000`
Defines a capture length of 2000 samples.

CONFigure:ADDRess<instid> <IPAddress>

This command defines the network address for a connection with measurement equipment.

Parameters:

<IPAddress> String containing the instrument's IP address.

Example: `CONF:ADDR '192.168.0.1'`
Defines a TCP/IP connection with a corresponding address.

CONFigure:CHANnel <RTOChannel>

This command selects the channel the signal is applied to on an oscilloscope.

Parameters:

<RTOChannel> CH1 | CH2 | CH3 | CH4

The available number of channels depends on the hardware configuration of the oscilloscope.

*RST: CH1

Example: `CONF:CHAN CH1`

Selects channel 1 as the measurement channel.

CONFigure:COUPling <RTOCoupling>

This command turns the 1 MOhm coupling of the oscilloscope on and off.

Parameters:

<RTOCoupling> **DC50**

Selects 50 Ω impedance.

DC1M

Selects 1 MΩ impedance.

*RST: DC50

Example: `CONF:COUP DC1M`

Turns the 1 MOhm coupling on.

CONFigure:NFC:BITRate <NFCBitrate>

This command selects the bitrate of the signal.

Parameters:

<NFCBitrate> **AUTO**

Automatically detects the data rate.

BR106

Selects 106 kbit/s.

BR212

Selects 212 kbit/s.

BR424

Selects 424 kbit/s.

Example: `CONF:NFC:BITR AUTO`

Automatically detects the bitrate.

CONFigure:NFC:STANdard <NFCStandard>

This command selects the NFC modulation type.

Parameters:

<NFCStandard>

AUTO
Automatically detects the modulation type.

NFCA
Selects modulation type NFC-A.

NFCB
Selects modulation type NFC-B.

NFCF
Selects modulation type NFC-F.

Example: `CONF:NFC:STAND NFCB`
Selects the NFC-B.

CONFigure:POWer:AUTO <State>

This command turns automatic determination of the (reference) level on and off.

Parameters:

<State> ON | OFF

*RST: ON

Example: `CONF:POW:AUTO OFF`
Turns off automatic determination of the level.

DISPlay:TRACe:Y:RLEV <RefLevel>

This command defines the expected signal level (reference level).

This command is available if `CONFigure:POWer:AUTO` is off.

Parameters:

<RefLevel> Level value in dBm.

*RST: -6.00 dBm

Example: `DISP:TRAC:RLEV -5`
Defines a level of -5 dBm.

TRACe:IQ:SRATe <Samplerate>

This command defines the sample rate.

Parameters:

<Samplerate> Sample rate in Hz.

*RST: 20 MHz

Example: `TRAC:IQ:SRAT 10MHZ`
Defines a sample rate of 10 MHz.

TRIGger:HOLDoff[:VALue] <HoldOff>

This command defines the trigger holdoff.

Parameters:

<HoldOff> Holdoff time seconds.

*RST: 10.0 µs

Example: `TRIG:HOLD 15us`

Defines a holdoff time of 15 µs.

TRIGger:LEVel:AUTO <State>

This command turns automatic definition of the trigger level on and off.

Parameters:

<State> ON | OFF

*RST: ON

Example: `TRIG:LEV:AUTO ON`

Turns automatic trigger level configuration on.

TRIGger:LEVel[:VALue] <TrigLevel>

This command defines the trigger level.

The trigger level is available for all trigger types and if `TRIGger:LEVel:AUTO` is off.

Parameters:

<TrigLevel> Trigger level in Volt.

*RST: 1.4 V

Example: `TRIG:LEV 2V`

Defines a trigger level of 2 Volt.

TRIGger:MODE <NFCBitrate>

This command selects the trigger type or source.

Parameters:

<NFCBitrate>

EXTernal
Selects the External trigger.

IFPower
Selects the IF Power trigger.
Available for measurments with R&S FSL, R&S ZVL and R&S FSV.

IMMediate
Selects no trigger source (Free Run mode).

NFCA | NFCB | NFCF212 | NFCF424
Selects one of the NFC triggers.
The characters after NFC define the standard and, in case of the NFC-F standard, the bitrate.
Available for measurements with R&S RTO.

Example: `TRIG:MODE EXT`
Selects an external trigger source.

TRIGger:OFFSet:AUTO <State>

This command turns automatic determination of the trigger offset on and off.

Parameters:

<State> ON | OFF

*RST: ON

Example: `TRIG:OFFS:AUTO ON`
Turns automatic trigger offset determination on.

TRIGger:OFFSet[:VALue] <Offset>

This command defines the trigger offset.

The trigger offset is available for all trigger types and if `TRIGger:OFFSet:AUTO` is off.

Parameters:

<Offset> Trigger offset in samples.

*RST: 0

Example: `TRIG:OFFS 10`
Defines a trigger offset of 10 samples.

Glossary: NFC Terms

A

ASK transition: see Low level state

B

Bit sequence: Series of bits that contains the information to be transmitted from one device to another.

Burst: Change in the radio frequency power resulting from the transmission of data from one device to another. The duration of a burst corresponds to the amount of data contained in one frame.
A change in the radio frequency power occurs when modulation is applied to the carrier signal for a short time. When a device sends data, you can observe multiple drops in the carrier signal level, resulting in low level states (or low state transitions).

C

Carrier signal: Continous wave signal supplied by the poller providing the power for data transmission.
In its original state, the carrier signal is unmodulated. When a transmission is initiated, modulation is applied to the carrier signal, resulting in a change of the power level.

Command: A command is a instruction from one device to another.
A command is either a request by the poller or a response by the listener.

F

Frame: Group of data bits that is transferred from one device to another.
The format of a frame depends on the modulation type, the type of information that is transmitted and the direction of the transmission (poller → listener or listener → poller.

H

High level state: State of the carrier signal when no modulation is applied.

L

Listener: Passive device in a NFC communication that reacts to a request in the communication and receives the necessary power from the poller.

Load modulation: Variation of an electromagnetic field by a passive communication device in order to receive the power required for the data transmission.

Low level state: State of the carrier signal during the period when modulation is applied and the power level drops.

Low state transition: Period in which the signal enters the Low level state and goes back to the High level state

M

Measurement equipment: Equipment necessary to test NFC devices. For a list of supported equipment see "Measuring signals" on page 11.

Modulation type: Near Field Communication (NFC) modulation type as defined by the NFC Forum.
Currently three NFC modulation types with different bitrates are defined: NFC-A, NFC-B and NFC-F.

N

NFC: Near Field Communication.
Term to decribe a technology that allows smartphones or similar devices to establish radio communication with each other. For successful communication, the devices usually are only a few centimeters apart. Applications are , e.g. contactless transactions or data exchange.
Communication between two NFC devices usually consists of a (poller) request and (listener) response.

NFC Forum: The NFC Forum is a non-profit industry association that promotes and specifies the use of NFC short-range wireless interaction in consumer electronics, mobile devices and PCs.

O

Overshoot: Signal state, when, after the low level state, the signal level rises and overshoots the original carrier level before it settles again.

P

Poller: Active device in a NFC communication that initiates the communication and supplies the necessary power.

R

Reference equipment: A set of reference poller and reference listener.
The reference equipment has been specified by the NFC Forum and has been designed to allow for valid testing of the RF characteristics of an NFC device.

S

Standard: Specification documents by the NFC Forum.

U

Undershoot: Signal state, when, in the process of modulation, the signal level is under a specified level for a short time, before reaching the targeted signal level.

List of Commands

Index

Symbols

B

C

D

E

F

G

H

I

L

M

N

O

P

R

S

T

U

Z