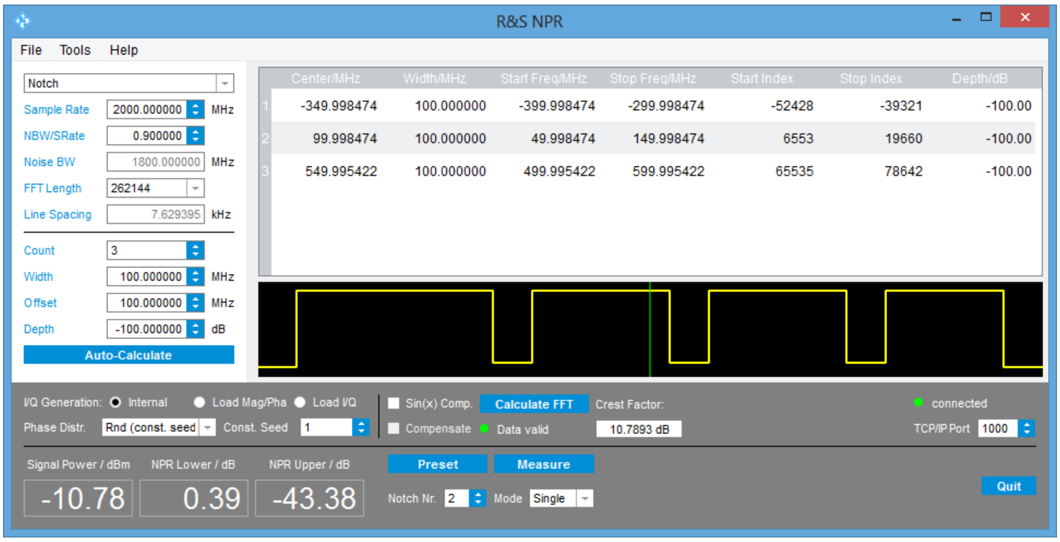
NPR – Noise Power Ratio Signal Generation and Measurement

Application Note

Products:

- R&S®SMW200A
- R&S®SMU200A
- R&S®AFQ100A/B
- R&S®SMBV
- R&S®FSW
- R&S®FSVR
- R&S®FSV
- R&S®FSL



Noise Power Ratio (NPR) is an add-on tool for WinIQSIM / WinIQSIM2™ to generate noise power ratio stimulus signals and measure the resulting noise power ratio of a device under test (DUT) using Rohde & Schwarz instruments via IEEE or LAN interface.

Please find the most up-to-date document on our homepage http://www.rohde-schwarz.com/appnote/1MA29.

This document is complemented by software. The software may be updated even if the version of the document remains unchanged

Application Note
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10.2015 - 1MA29_13e

ROHDE&SCHWARZ

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1 Overview

Noise Power Ratio (NPR) is an add-on tool for WinIQSIM / WinIQSIM2™ to generate noise power ratio stimulus signals and measure the resulting noise power ratio of a device under test (DUT) using Rohde & Schwarz instruments via IEEE or LAN interface. The Noise Power Ratio measurement technique can characterize the linearity of a wide band amplifier over a custom frequency range. Since NPR drastically reduces measurement time compared to classic gain wobbling, it is particularly interesting for production specific applications.

The following abbreviations are used in the following text for R&S® test equipment:

- R&S® is a registered trademark of Rohde & Schwarz GmbH und Co. KG.
- The R&S®FSW Spectrum Analyzer is referred to as FSW.
- The R&S®FSQ Spectrum Analyzer is referred to as FSQ.
- The R&S®SMW200A Vector Signal Generator is referred to as SMW.
- The R&S®SMU200A Vector Signal Generator is referred to as SMU.
- The R&S®SMBV Vector Signal Generator is referred to as SMBV.

2 Software Features

The software offers:

- Custom notch definition
- Frequency response compensation
- Generator and analyzer control
- Load / save device configuration
- Automatic measurement of specified notch with adjacent channel power (ACP) option

3 Hardware and Software Requirements

3.1 Hardware Requirements

The software runs on a PC with:

- CPU: 1 GHz or faster
- RAM: 2 GBytes or more
- Monitor: VGA color monitor
- GPIB bus: VISA compatible GPIB controller board and / or LAN Standard on-board 100/1000 MBit/s controller or switch / hub.

It supports following instruments:

- AFQ100, AMIQ: I/Q modulation generator
- SMW, SMBV, SMJ, SMV03, SMU, SFU, SMIQ, SMHU58: Vector Signal Generator with I/Q inputs or internal I/Q modulator.
- FSL, FSP, FSQ, FSU, FSV, FSW, FSE, FSIQ spectrum analyzer with ACP capability.
- SMF, SMR microwave generator supported, but not mandatory.

3.2 Software Requirements

- **MICROSOFT WINDOWS 7/8/10** 32- or 64-bit operating system.
- Optional **GPIB** bus driver.
- **WINIQSIM V4.4** or **WINIQSIM2™ V2.20.XXX** (or higher) installed. This is a software tool that generates standard and custom I/Q signals e.g. for *ACP* measurements. It can upload I/Q data to an AFQ / SMU I/Q modulation generator and control one of the SMx signal generators named above. NPR communicates with WinIQSIM / WinIQSIM2™ via the TCP/IP network protocol. Both programs must run simultaneously to enable data transfer. Download the latest **WINIQSIM** version from http://www.rohde-schwarz.com.
- **VISA** compatible driver. See manufacturer's website for latest revision.

4 Connecting the Computer and Instrument

Connect the computer running NPR to the instruments that are involved with the measurement, such as a SMx signal generator and an FSx spectrum analyzer.

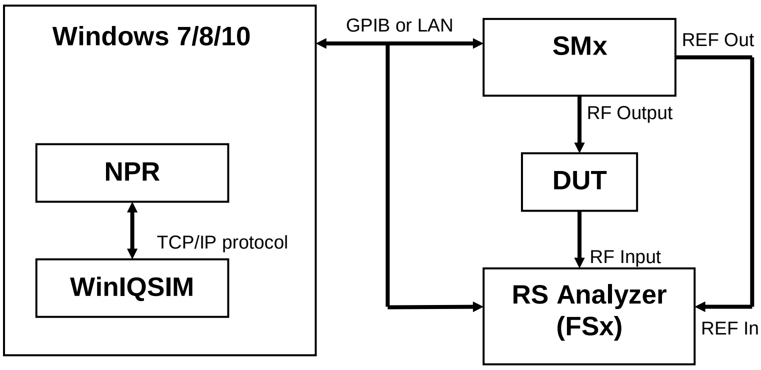

Fig. 4-1: Connecting Instruments

5 Installing NPR

Make sure that **WINIQSIM** or **WINIQSIM2™** is installed on your hard disc. Execute **1MA29_NPR_x64_****.EXE** or **1MA29_NPR_x86_****.EXE** and follow the installation instructions.

6 Starting the Software / Measurement

Execute **NPR.EXE**. The example setup below shows three notches generated with **AUTO-CALCULATE**. NPR configuration is stored in **NPR.CFG** at exit:

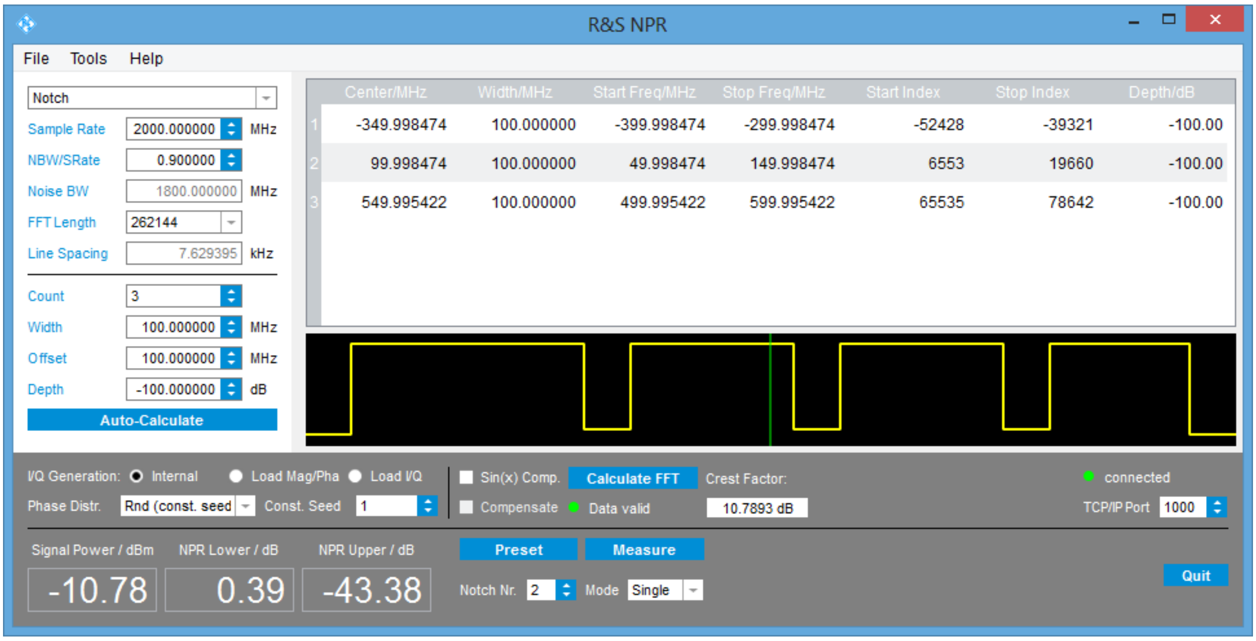

Fig. 6-1: Main Menu

Devices can be configured in the device menu. See **DEVICES** for details.

- Define a custom signal with the sampling and notch specific parameters (**SAMPLE RATE**, **FFT LENGTH**, **NOTCH COUNT**, etc.).
- Prepare the IQ data for transmission to WinIQSIM by pressing **CALC FFT**. The **DATA VALID** LED indicates that the data is ready for transfer.
- After transferring the data to the SMU/AMU via WinIQSIM (see following section, step 4) press the **PRESET NPR MEAS** button to put the analyzer in ACP measurement mode.
- Select a **NOTCH NR** and press the **MEASURE** button to receive the signal's **NPR** and calculated **SIGNAL POWER**.

Execute **WINIQSIM.EXE** / **WINIQSIM2.EXE** and load the configuration file **NPR.IQS**. / **NPR.SAVRCL** This affects following settings:

1. **IMPORT** settings for TCP/IP link.

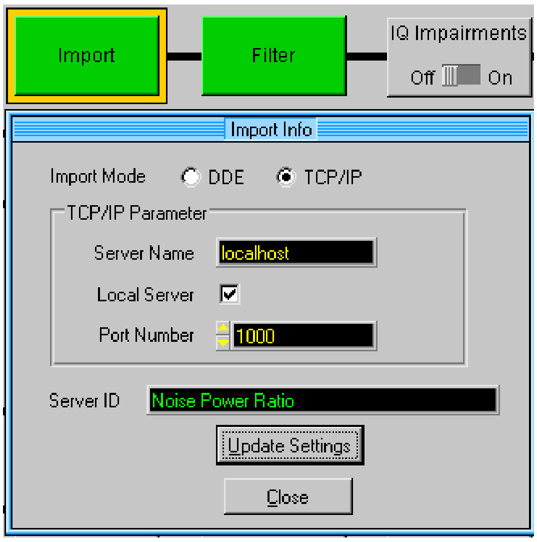

Fig. 6-2: WinIQSIM Import Settings

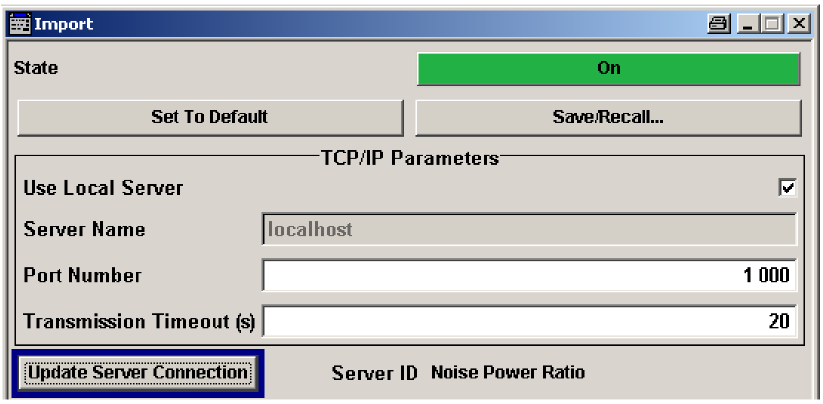

Fig. 6-3: WinIQSIM2™ Import Settings

2. **FILTER** set to ideal low pass.

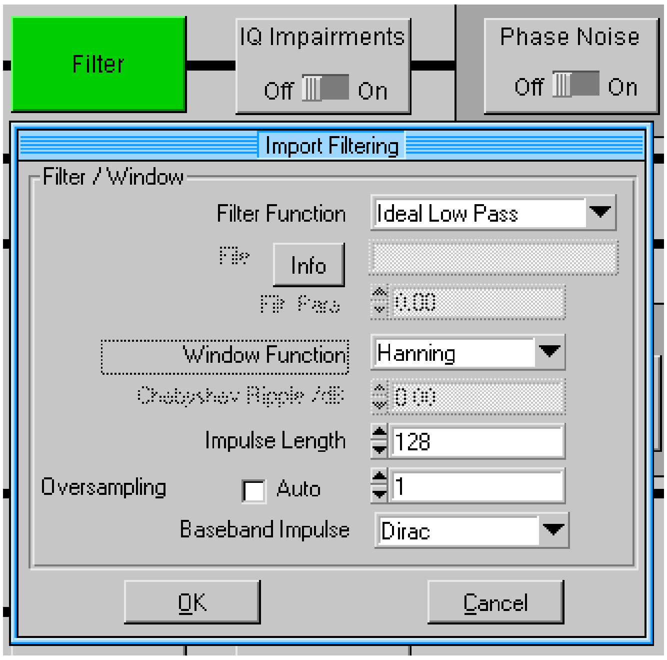

Fig. 6-4: WinIQSIM Filter Settings

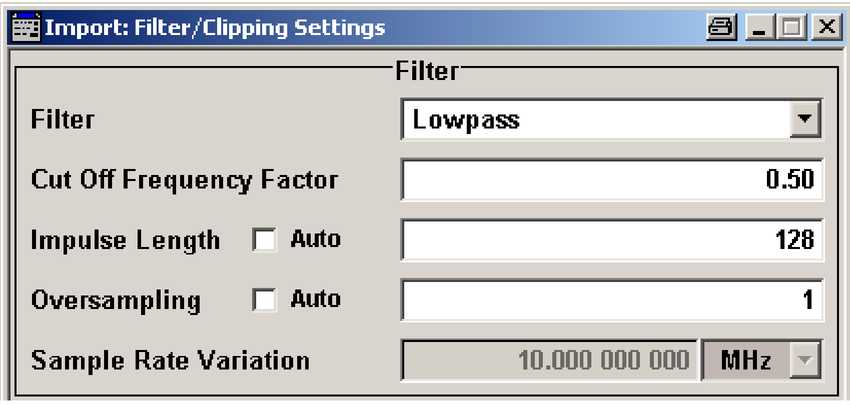

Fig. 6-5: WinIQSIM2™ Filter Settings

3. Graphic Display

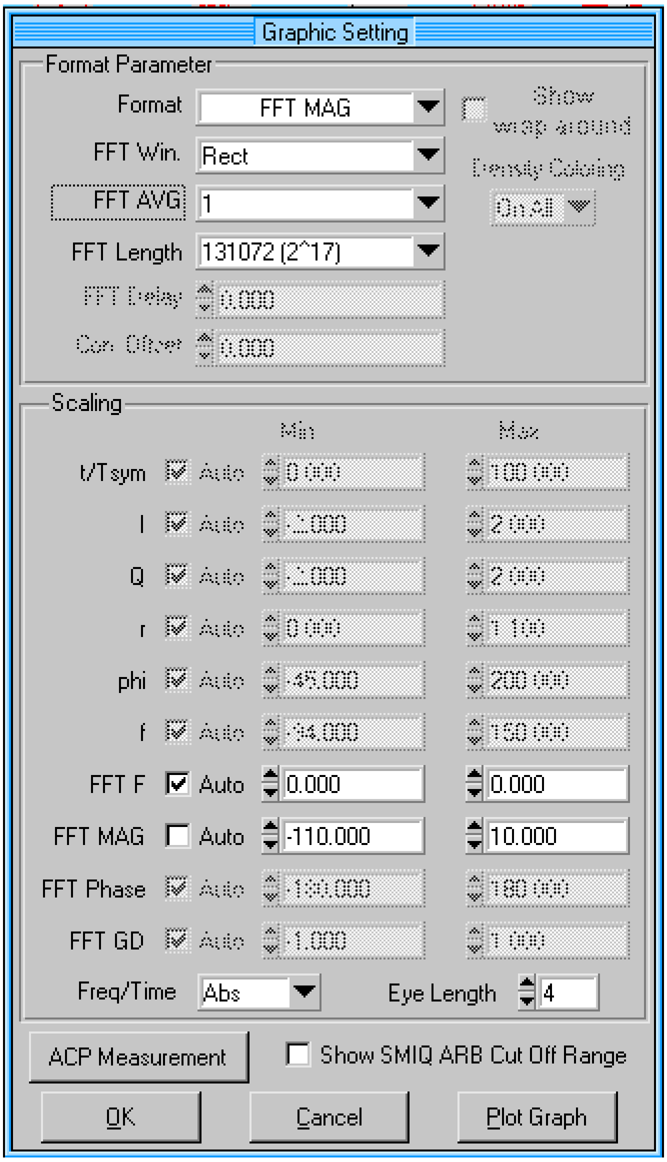

Fig. 6-6: WinIQSIM Graphic Setting

Be sure to run **NPR** before **WinIQSIM** / **WinIQSIM2** at restart to avoid a **TCP/IP** warning. After pressing the **Update** button in the WinIQSim graphics window the following display appears.

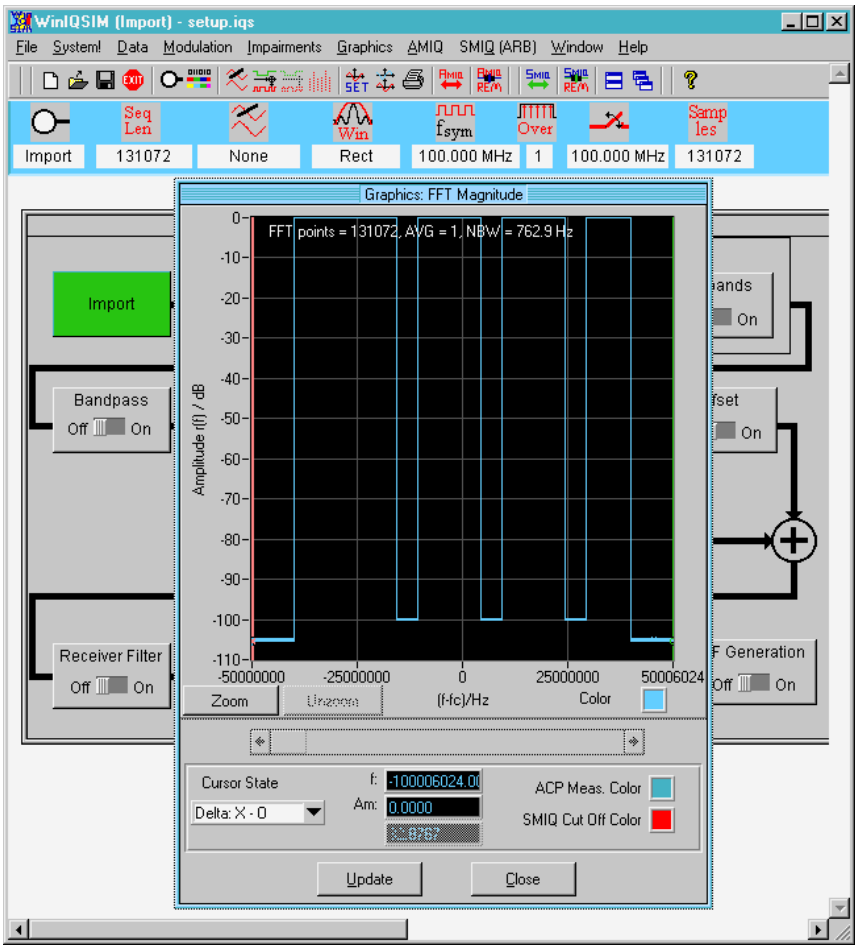

Fig. 6-7: WinIQSIM Graphic Display

The WinIQSIM2™ graphic display is automatically updated when a parameter is changed in NPR.

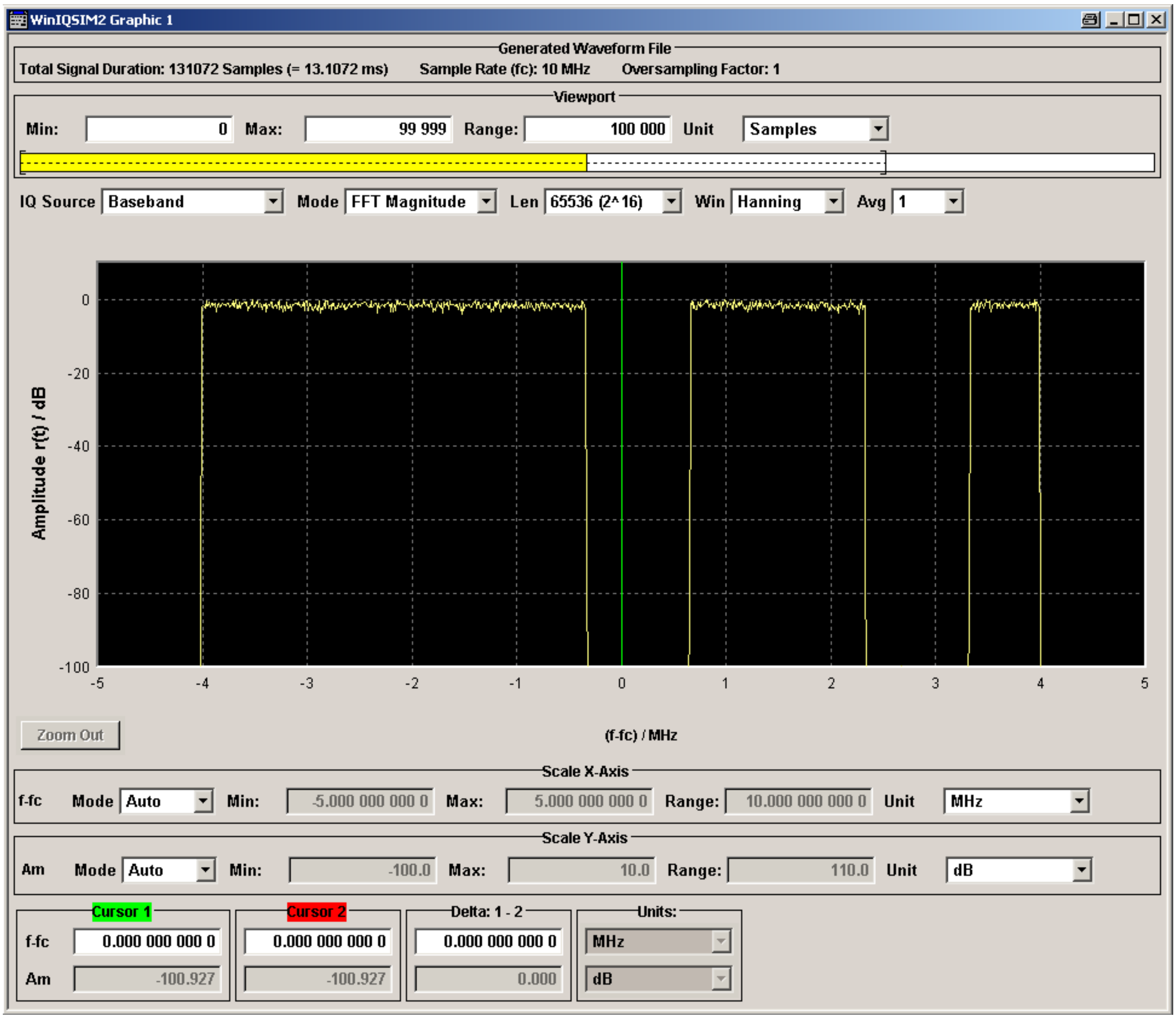

Fig. 6-8: WinIQSIM2™ Graphic Setting and Display

4. To transfer the signal to the arbitraty IQ generator press the WinIQSim menu item **ARB -> SELECT TARGET ARB** and choose one from the list.

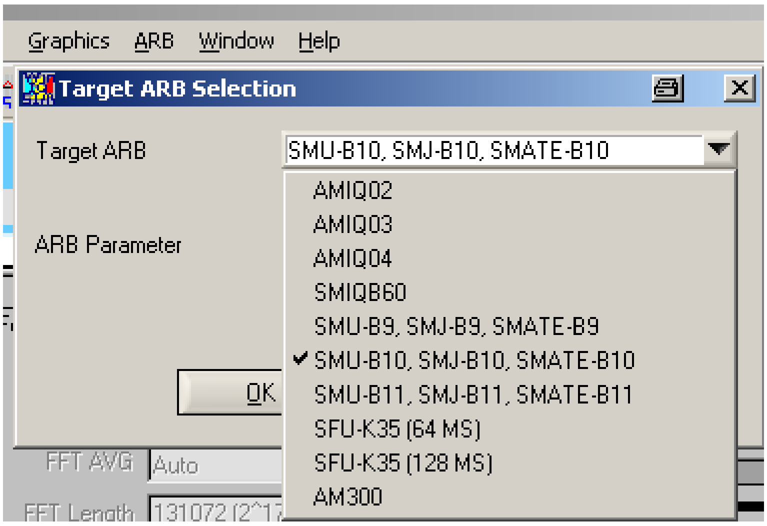

Fig. 6-9: WinIQSIM Target ARB Selection

Then choose ARB → SMU, SMJ, SMATE (ARB) → **TRANSMISSION.**

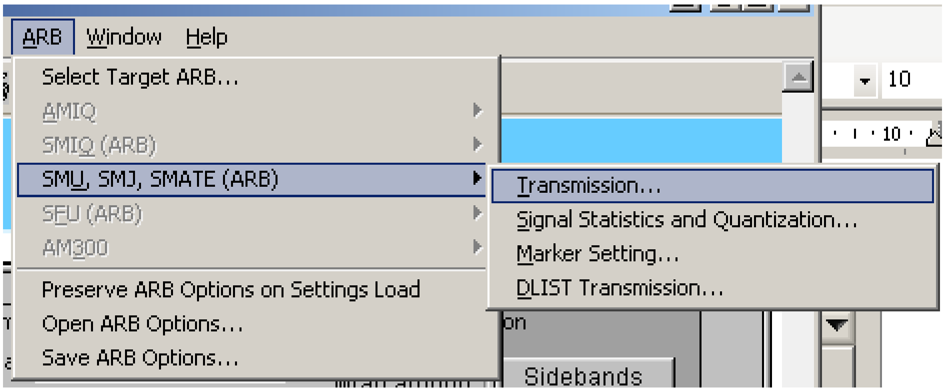

Fig. 6-10: WinIQSIM AMIQ Transmission

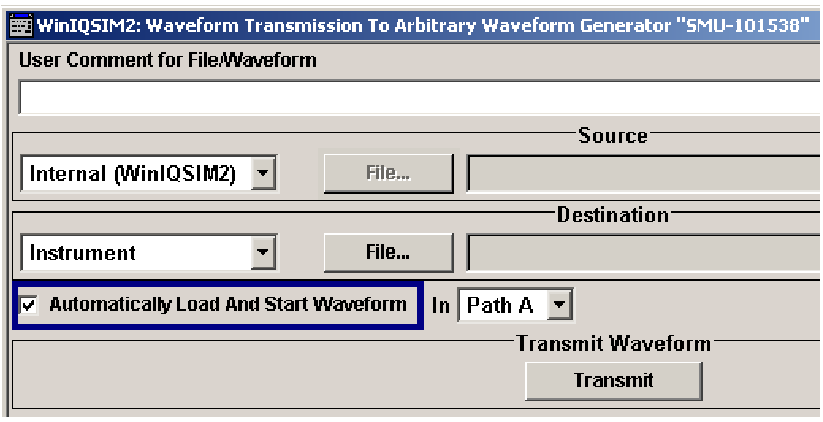

Fig. 6-11: WinIQSIM2™ SMU Transmission

5. **NPR** can set up the analyzer for Noise Power Ratio measurement of a specified notch automatically (see *Performing NPR Measurements*). Following analyzer parameters are affected.

Detector *RMS*
Resolution bandwidth: manual < *30ms* depending on sample rate.
Sweep time > *0.5s*
*Channel bandwidth = notch width * 0.8.*
*Channel spacing = notch width * 1.1*
*C*enter frequency is moved so adjacent channel fits inside notch.

The analyzer (e.g. FSP) would show following display. The adjacent channel fits perfectly into the second notch (cu1 - ACP upper). If the notch's mid frequency is smaller than the generator's center frequency then cl1 - ACP lower channel is used.

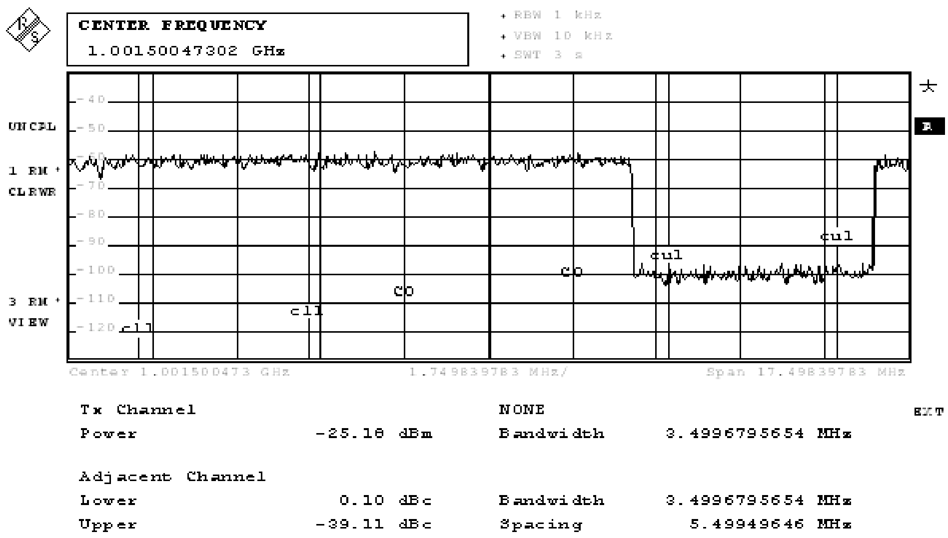

Fig. 6-12: FSP ACP Display

6.1 Parameters

6.1.1 Sampling Parameters

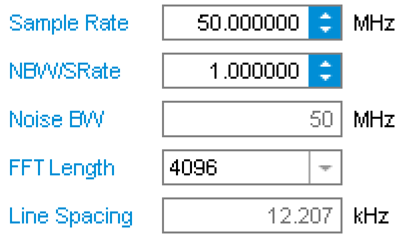

Fig. 6-13: Sampling Parameters

SAMPLE RATE – Configures the ARB sample rate. This value affects the **LINE SPACING** display. A noise and notch pattern can be minimized by decreasing and expanded by increasing the sample rate. Range: 10 kHz – 10 GHz.

NOISE BW / SAMP.RATE – Configures the noise bandwidth to sample rate ratio. This limits the noise bandwidth to prevent upper and lower side band aliasing effects from influencing the signal. Range: 0.01 to 1.

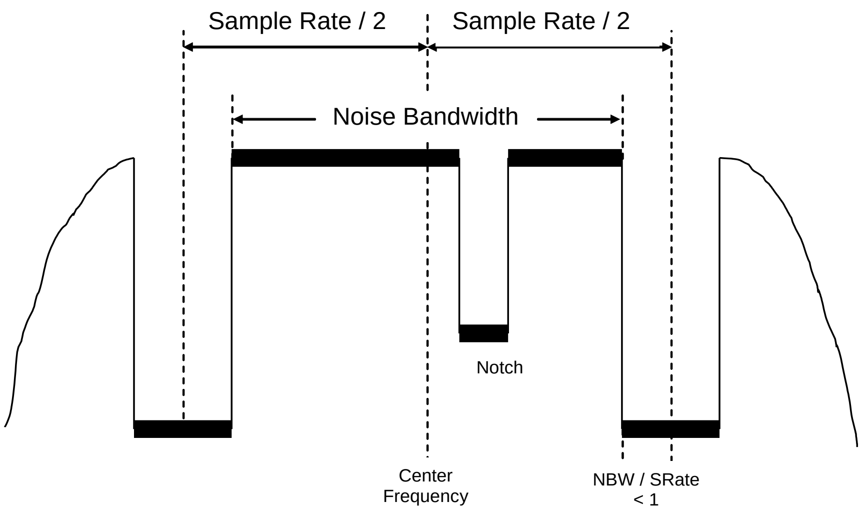

Fig. 6-14: Noise BW / Sample Rate

NOISE BANDWIDTH (NBW) – Displays the valid spectral area for custom notch insertion, which is:

NBW = Sample Rate * NBW / Srate

FFT LENGTH – the number of points in the frequency domain axis that are inversely Fourier transformed into time domain mode for download to WinIQSIM. This value affects the **LINE SPACING** display.

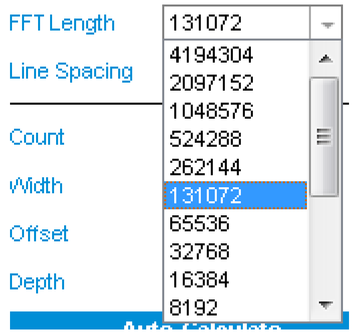

Fig. 6-15:FFT Length

The latest WinIQSIM revision 3.5 can only display FFT lengths up to 128kS correctly.

LINE SPACING – Displays the frequency resolution of FFT lines, which is:

LINE SPACING = SAMPLE RATE / FFT LENGTH

6.1.2 Notch Related Parameters

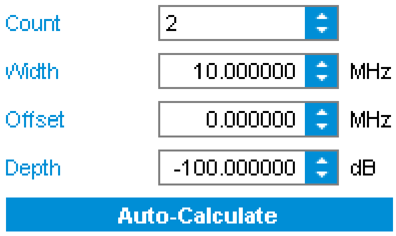

Fig. 6-16: NPR Notch Related Parameters

NOTCH COUNT – Specifies the number of notches within the current noise bandwidth. With **AUTO CALC NOTCHES** the number of notches is restricted to:

$$\textit{NOTCH COUNT} \leq \textit{NBW} / \textit{NOTCH WIDTH}$$

NOTCH WIDTH – The notch width is limited by the current noise bandwidth. With **AUTO CALC NOTCHES** all notches have equal widths. If the notch width is smaller than the line spacing no notch will be generated. Range: 0.01 MHz - Noise Bandwidth.

NOTCH DEPTH – With **AUTO CALC NOTCHES** all notches have equal depths. Range: 0 - 100 dB.

NOTCH OFFSET – Specifies a frequency offset that is added to the notch center frequencies with **AUTO CALC NOTCHES**. Avoid effects from insufficiently suppressed carriers by moving the notch out of the "*danger zone*".

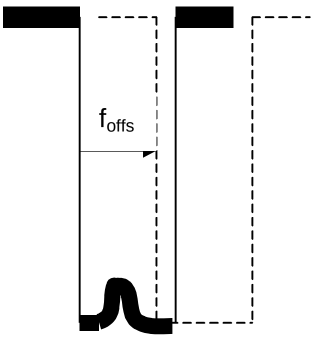

Fig. 6-17:NPR Notch Offset

AUTO-CALCULATE – Automatically produces notches with the specified parameters to fit perfectly into the noise bandwidth range. The *Notch Count* is reduced, if necessary.

NOTCH / CARRIER – Generates Notches as defined above, if set to Notch.

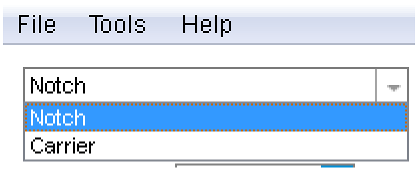

Fig. 6-18: Notch / Carrier selction

Generates <Count> carriers after pressing Auto-Calculate if set to Carrier.

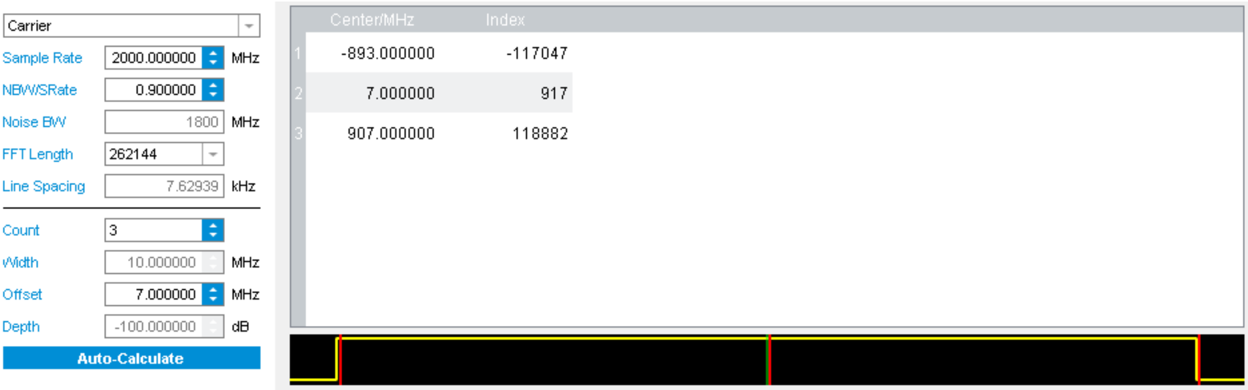

Fig. 6-19: Generate Carriers

6.1.3 Phase / Magnitude Distribution

Fig. 6-20: Phase / Magnitude Distribution

PHASE DISTRIBUTION

RANDOM (CONST. SEED) – I/Q-phase arrays are filled with random values between $-\pi$ and $+\pi$. The random generator always starts with ***Const.Seed***.

RANDOM (CONTINUE) – as above except that the random generator's seed depends on the last value.

PARABOLIC – I- and Q- phase arrays are filled with an unsymmetrical chirp signal ranging from $-\pi$ to $+\pi$. This signal can be used to simulate a wobble generator.

CONSTANT – I/Q phase arrays are filled with constant values. This signal results in one or more peaks in time domain mode due to identical phases of numerous frequency lines.

I/Q GENERATION – Allows **INTERNAL** I/Q generation with the Phase Distributions above, loading a Magnitude / Phase (*.pmc) or I/Q data file.

Fig. 6-21: I/Q Generation

In case of **LOAD I/Q**, the FFT Length is changed to the number of samples in the file.

If Load Mag/Pha is checked, the selected *.pmc file is loaded. After loading the file the FFT length input field is dimmed and the number of FFT elements in the file is used. The file has the structure shown below.

```
4096 Element count (usually based on 2^n)

0        -3.1415e0    0.95
|             |           |
|             |           magnitude (range 0.0 to 1.0)
|             |
|             phase offset (range ±π)
|
Index nr (range 0 to element count)
......

4095  2.4567e0  0.34
```

6.1.4 Notch List

All active fields (not dimmed) of the notch list can be edited except *Notch* index. If there are more than 10 items use the scroll bar to display the desired notch configuration line. Since all values are based on a discrete 2^N array it is likely that a straight value, e.g. 10.00000 is locked to the nearest point in the array, e.g. 9.987654. The resolution depends on the FFT length.

	Center/MHz	Width/MHz	Start Freq/MHz	Stop Freq/MHz	Start Index	Stop Index	Depth/dB
1	982.000351	5.000000	979.500351	984.500351	-53738	-40631	-100.00
2	1006.999969	5.000000	1004.499969	1009.499969	11796	24903	-100.00
3	1031.999969	5.000000	1029.499969	1034.499969	77332	90439	-100.00

Fig. 6-22: Notch List

Note: *All values displayed in one line depend on each other.The last input value reconfigures the other ones to make sense.*

NOTCH – Displays the notch index number.

CENTER FREQ – Edit notch center frequency. Range:

$$f_{carrier} - NBW / 2 \leq f_{center} \leq f_{carrier} + NBW / 2$$

WIDTH – Specifies the notch width. Range: 0 - *NBW*.

START FREQUENCY – The start frequency is calculated as:

$$f_{start} = f_{center} - Width / 2$$

STOP FREQUENCY – The stop frequency is calculated as:

$$f_{stop} = f_{center} + Width / 2$$

START INDEX – Notch's first frequency line number. Range:

FFT Length / 2 - FFT length * (NBW / SRate) / 2 ≤ Start Index < FFT Length / 2 + FFT length * (NBW / SRate) / 2

STOP INDEX – Notch's last frequency line number. Range: see *Start Index*.

Note*: An automatic plausibility check avoids* Start Frequency *(*Start Index*) being larger than* Stop Frequency *(*Stop Index*) and switches them, if necessary. If* Start- *and* Stop Index *are equal, the notch consists of only one frequency line. On the other hand a single frequency can be generated by defining two notches ranging from minimum index to frequency index-1 and frequency index + 1 to maximum index.*

DEPTH – Specifies the notch depth. Range: 0 - -100 dB.

Note*: While WinIQSIM displays correct notch depths, the depth of the actual signal is limited to > -70dB by the AMIQ.*

6.1.5 Calculate FFT

Fig. 6-23: Calculate FFT

Press the **CALCULATE FFT** button to calculate the NPR signal in WinIQSIM compliant I/Q format. The green LED indicates that the data is valid and can be imported by WinIQSIM via TCP/IP. The crest factor of the signal is also calculated. The **COMPENSATE** checkbox is undimmed as soon as a trace file has been loaded from File → Load Trace Data (Text). The trace data file can be generated for instance with RSCommander (1MA74). When **COMPENSATE** is checked, the data from the trace file loaded previously is used to linearize the frequency response in the baseband.

6.1.6 Connected

Fig. 6-24: TCP/IP Connection Status

- When NPR and WinIQSIM / WinIQSIM2™ (TCP/IP import mode) are running the **CONNECTED** LED turns green to indicate that NPR has been recognized by WinIQSIM / WinIQSIM2™.
- The **TCP/IP PORT** number may be varied to enable multiple client access to WinIQSIM / WinIQSIM2™.

6.2 Menu

6.2.1 Load / Save Configuration or Data File

All program and device specific data can be loaded / saved from / to a configuration file.

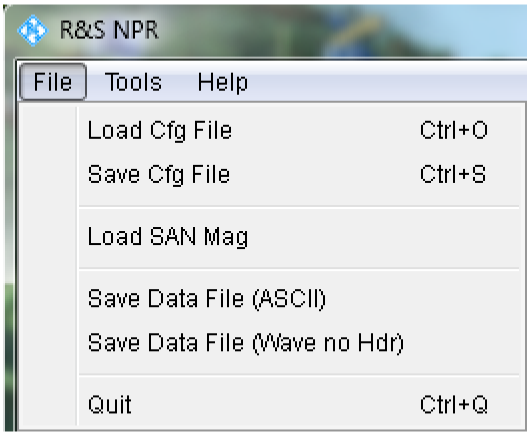

Fig. 6-25: File Menu

LOAD CONFIGURATION – the default file extension is **.cfg*.

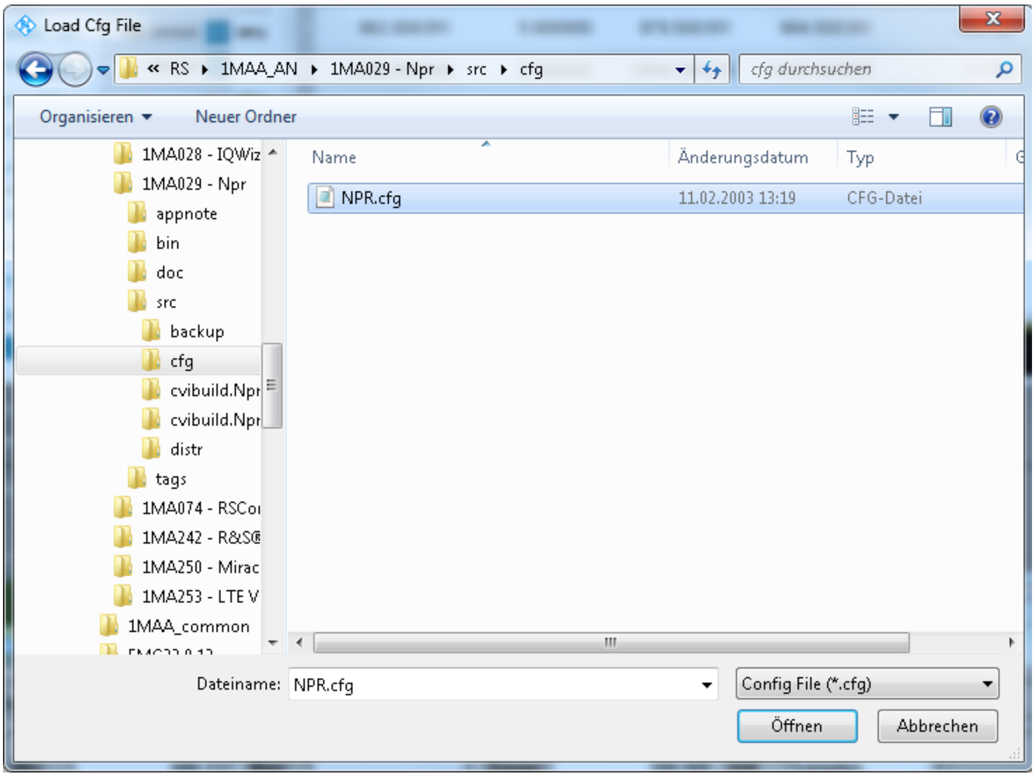

Fig. 6-26: Load Configuration

SAVE CONFIGURATION – the default file extension is **.cfg*.

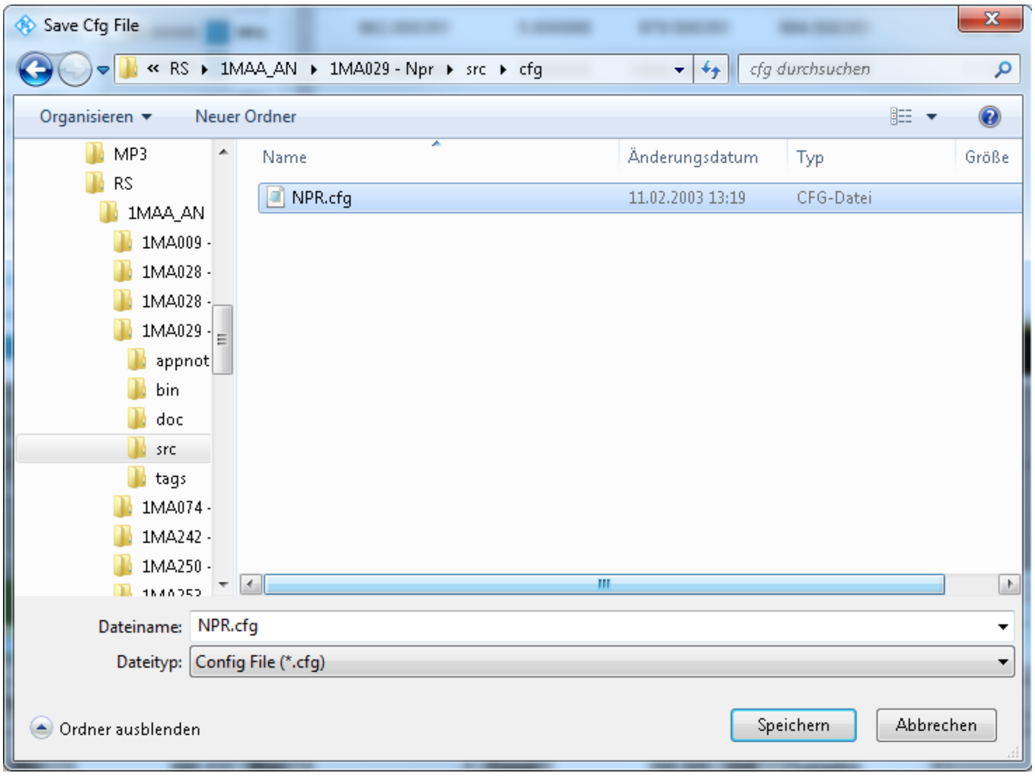

Fig. 6-27: Save Configuration

LOAD SAN MAG (POLYNOMIAL) – Loads a trace file (*.txt) that has been generated for instance with RSCommander (1MA74) with following format:

<frequency0[Hz]>;<level0[dB]>

…….

<frequency n-1[Hz]>;<level n-1[dB]>

This menu item compensates the frequency response of an IQ modulated signal with a polynomial function.

LOAD SAN MAG (DIRECT) – Loads a trace file (*.txt) that has been generated for instance with RSCommander (1MA74) with the same format as above. The compensation is performed by adding the negative offset of the trace file from the nominal level (as defined in the devices menu) to the internally generated signal.

6.2.1.1 Magnitude Compensation Example

1. Generate a wideband noise signal without notches (Notch Count = 0)

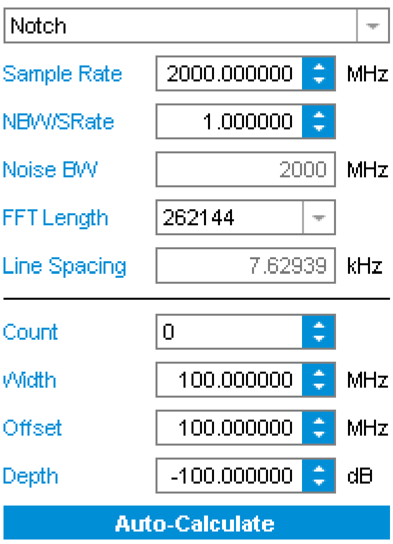

Fig. 6-28: Noise signal without notches

2. Press **CALC FFT** to generate the according I- and Q- arrays.
3. Either transmit the data to an R&S SMx generator via WinIQSIM2 or save the data to ASCII (*.i and *.q) or WAVE files (*_I.wav and *_Q.wav) e.g. for Tabor WX2182 Arbitrary Waveform Generator series.

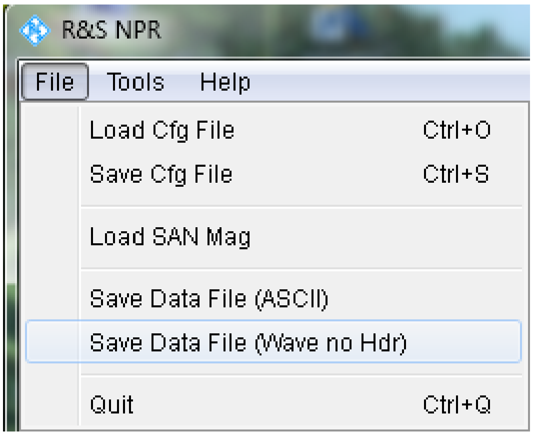

Fig. 6-29: Save I/Q Data as Wave without Header

4. Generate an IQ modulated RF signal and trace it with an FSx spectrum analyser. The span should be a bit larger than the NPR sample rate, set **SWEEP TIME** to 1 second and use a **RMS** detector.
5. Start RSCommander, perform a **TRACE** a save the trace data, e.g. Reference.txt.
6. Load the trace data into NPR (either with polynomial or direct offset compensation).

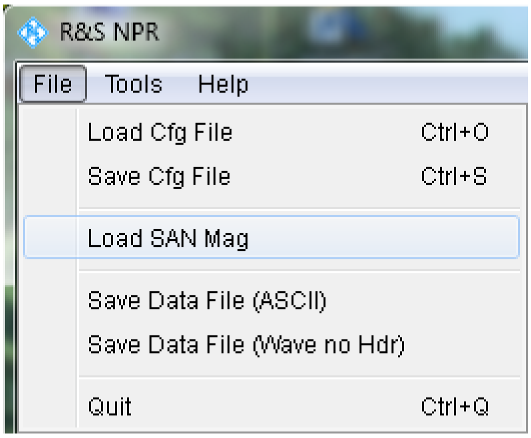

Fig. 6-30: Load FreRes curve and compensate with 20-degree polynomial function

7. Turn ON the **COMPENSATE** checkbox and generate a ‘real’ NPR signal with notches (Fig. 6-25).
8. Press **CALC FFT** to generate a compensated I/Q signal.
9. Transmit the signal as described in 3.).

SAVE DATA (ASCII) – Saves I- and Q-files (<filename>.i and <filename>.in ASCII format.

SAVE DATA (WAVE) – Saves I- and Q-files in RIFF wave format <filename>_i.wav and <filename>_q.wav.

Menu

6.2.2 Devices

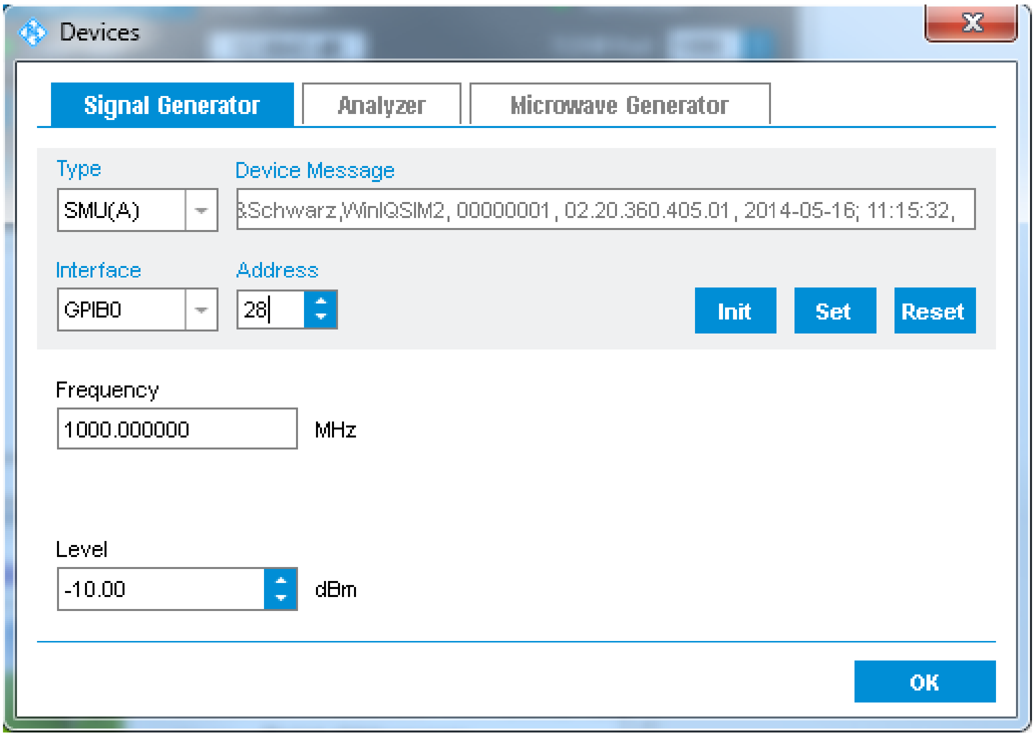

Fig. 6-31: Signal Generator Configuration

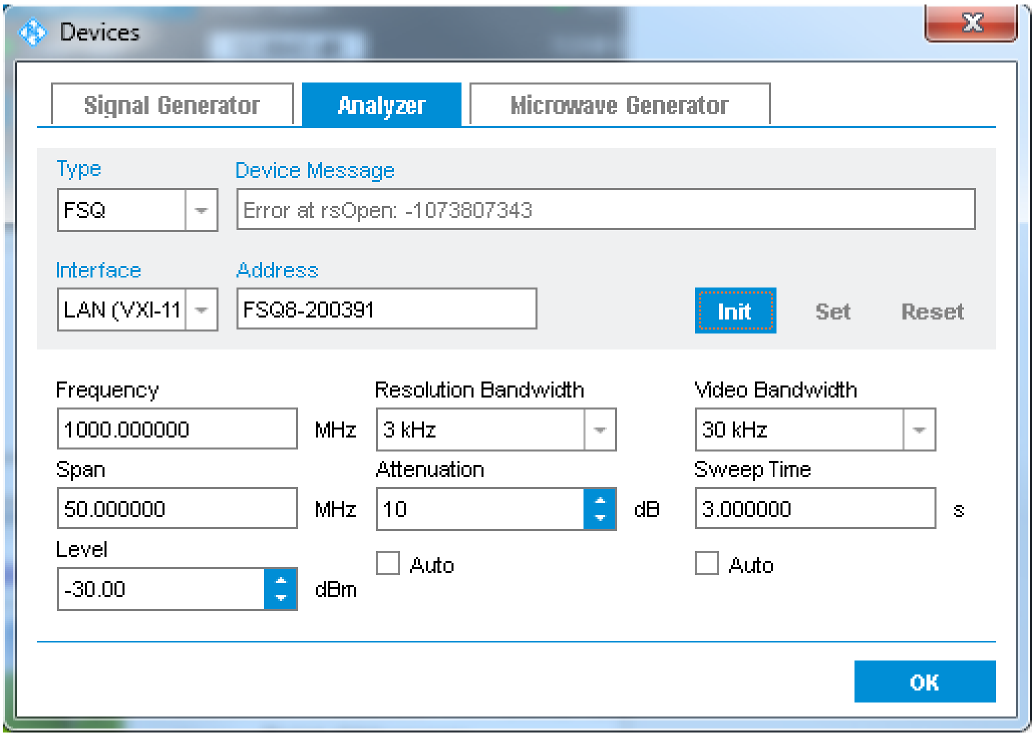

Fig. 6-32: Analyzer Configuration

SIGNAL GENERATOR

TYPE	**SMBV, SMG, SMHU58, SMIQ, SMJ, SMU(A), SMU(B) , SMV, SMW(A), SMW(B)**
INTERFACE	GPIB0, GPIB1, LAN (RSIB), LAN (VXI-11)
PAD	GPIB **P**rimary **AD**dress. Range 1...31
IP ADDR	IP Address e.g. 192.168.1.1 or instrument name e.g. FSQ8-100234
RESET	Performs an instrument reset when pressing **INIT** or **SET**.
INIT	Initializes generator and ID string.
SET	Sets generator frequency and RF level.
FREQ	Specifies the generator's carrier frequency. Range depends on the generator type. With no generator connected, this value ranges from -∞ to +∞.
LEVEL	RF output level. Range depends on the generator option.

ANALYZER

TYPE	**FSEx, FSG, FSIQ, FSL, FSP, FSQ, FSU, FSV, FSW**
PAD, IP ADDR, RESET, INIT, SET	See above
FREQ	Center frequency
SPAN	Displayed frequency range.
RLEV	RF reference level. Range depends on the analyzer option.
ATTEN	RF input attenuation. With **AUTO** checked the Atten value is calculated by the analyzer and depends on RF input and mixer level (in certain FSEx models).
RBW	Video bandwidth. Auto overrides manual setup.
VBW	Specifies the time needed to sweep over the complete frequency span. **AUTO** overrides manual setup.
SWP.TIME	Specifies the time needed to sweep over the complete frequency span. ***Auto*** overrides manual setup.

MICROWAVE GENERATOR

TYPE	**None, SMF, SMR**
PAD, IP ADDR, RESET, INIT, SET	see above.
FREQ	Microwave signal generator frequency. Acts as local oscillator (LO) frequency in the mixer stage (see USING NPR WITH MICROWAVES).
LEVEL	RF output level.
ATTEN	IFI input attenuation.
IF INPUT	Mixer input. **LEVEL** control is dimmed when **IF INPUT** is active.

6.2.3 Optimize Crest Factor

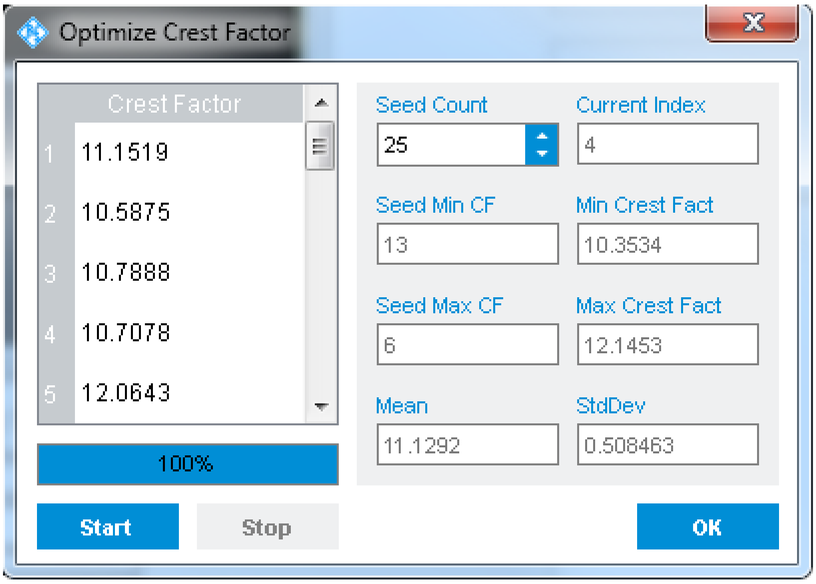

Fig. 6-33: Optimize Crest Factor

The **Optimize Crest Factor** option enables calculation of crest factors depending on the seed value. Enter **Seed Count** and press **Start** to begin calculation. **Stop** halts the calculation and **Quit** closes the window. All calculated values are listed in the left table. The **Min**imum and **Max**imum **Crest Factor**, the corresponding indexes (**Seed Min CF**, **Seed Max CF**) and **Mean** and **StdDev** (standard deviation) values are also displayed. The crest factor is defined as the ratio P_{peak} / P_{RMS} and usually ranges from 10 to 12 dB for NPR signals.

To calculate an NPR signal with a crest factor displayed in the list just enter the according seed in the **Const Seed** control of the main program window and press **Calc FFT**.

6.2.4 Performing NPR Measurements

The program can set up the devices to automatically perform a NPR measurement of a desired notch. The NPR program uses the *ACP* measuring capabilities of the supported *FSx* spectrum analyzers to obtain the noise power ratio of the notch.

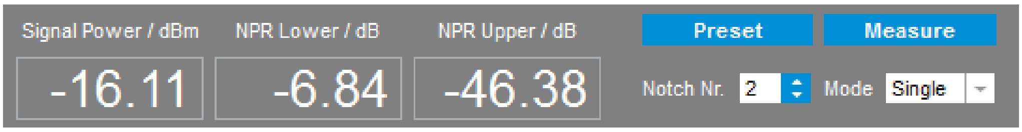

Fig. 6-34: NPR Measurements

PRESET – analyzer frequency, span, resolution bandwidth and sweep time are set up to get an overview of the complete sample rate.

NOTCH NR – configures the analyzer for NPR measurement of a selected notch. The center frequency is changed so the adjacent channel bandwidth area fits perfectly into the notch. The span is zoomed to increase precision. **ACP CHANNEL / ADJACENT CHANNEL BANDWIDTH** is set to 80% of the notch width while **CHANNEL SPACING** is 110% of the notch width. If the notch's mid-frequency is smaller than the generator's center *NPR* automatically chooses *ACP Lower* display (yellow background) else *ACP Upper*.

MODE – there are two measurement modes: *Cont*inous and *Single* shot. When choosing *Single* a measurement can be triggered by pressing the **MEASURE** button.

***Note**: Automatic measurement only works correctly if gaps between notches are at least as wide as the notches themselves. The following figure shows how the channel bandwidth power suddenly drops in the left notch and leads to an incorrect* NPR Upper *display.*

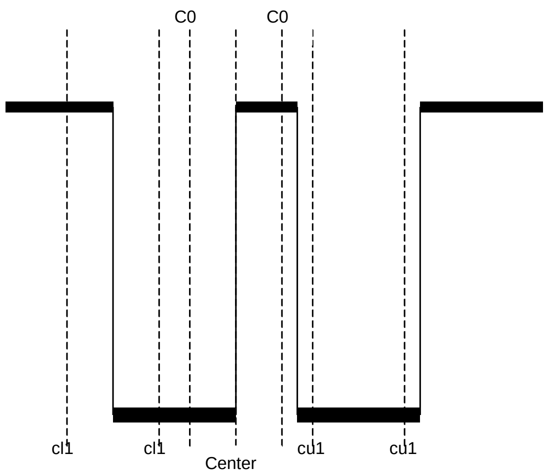

Fig. 6-35: Correct ACP Readout

6.2.5 Using NPR with Microwaves

An interesting application is NPR measurements of microwave amplifiers. For frequencies exeeding the range of standard signal generators (> 6 GHz) it is necessary to use an additional microwave generator e.g. SMR40 with the SMR-B24 or B23 mixer option. The schematic below shows an application consisting of SMU, SMR with a mixer option for signal generation and an FSx listed in the ORDERING INFORMATION table) for signal analysis.

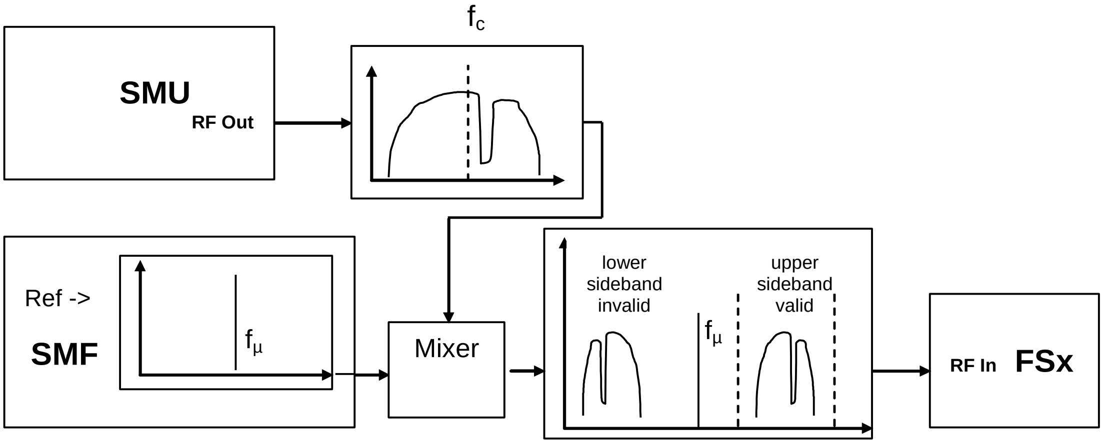

Fig. 6-36: NPR with Microwaves

The carrier frequency of the SMU (f_c) is mixed with the SMR microwave carrier frequency (f_μ) resulting in an upper ($f_\mu + f_c$) and lower ($f_\mu - f_c$) sideband. The most important SMR parameters (frequency, level and IF input attenuation and IF input on/off) can be controlled from the NPR device configuration menu.

In case the DUT is not frequency selective suppress the SMR carrier frequency and lower sideband with an external filter.

The resulting RF frequency is fµ + fc (upper sideband). The lower sideband is mirrored and therefore not adequate for our purposes. Our example uses the following setup: fµ = 10 GHz, fc = 500 MHz. Note that the resolution bandwidth is set to < 2 kHz and the sweep time is > 2 s. It is also possible to merge both signals via an external mixing component. This is necessary with an SMF microwave generator.

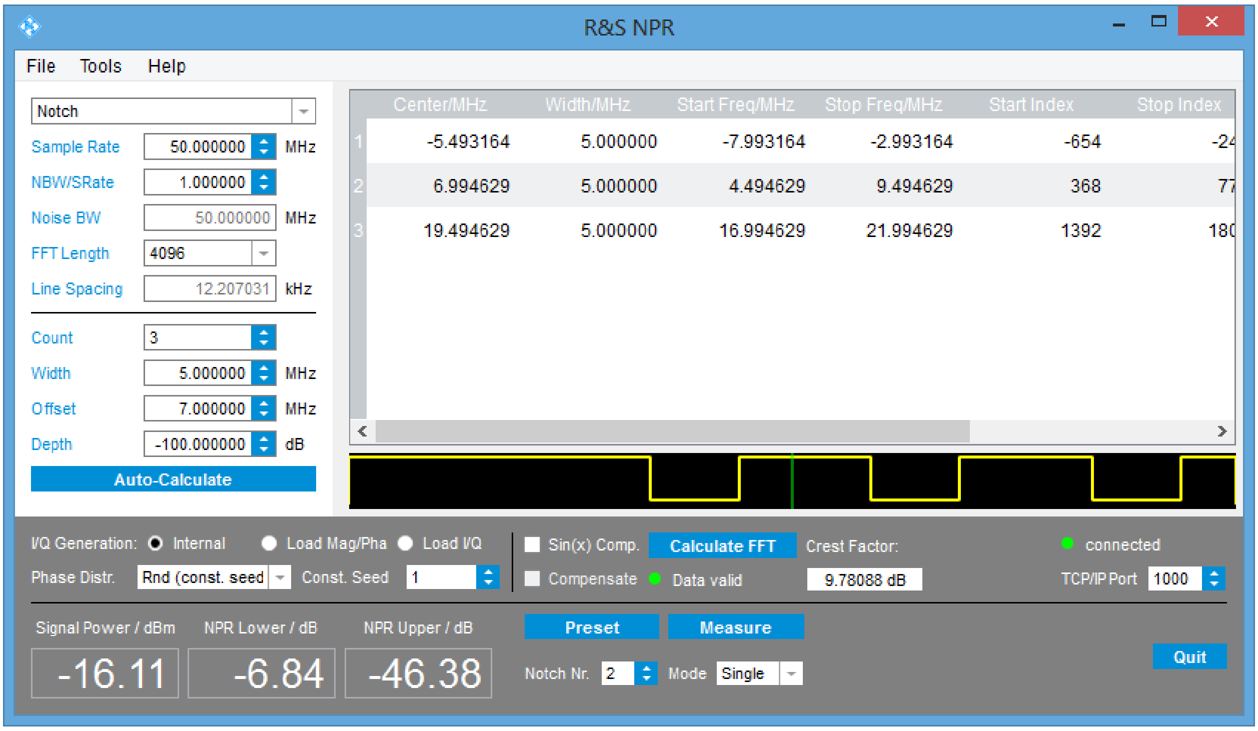

Fig. 6-37: NPR Microwave Example

WinIQSim graphic display.

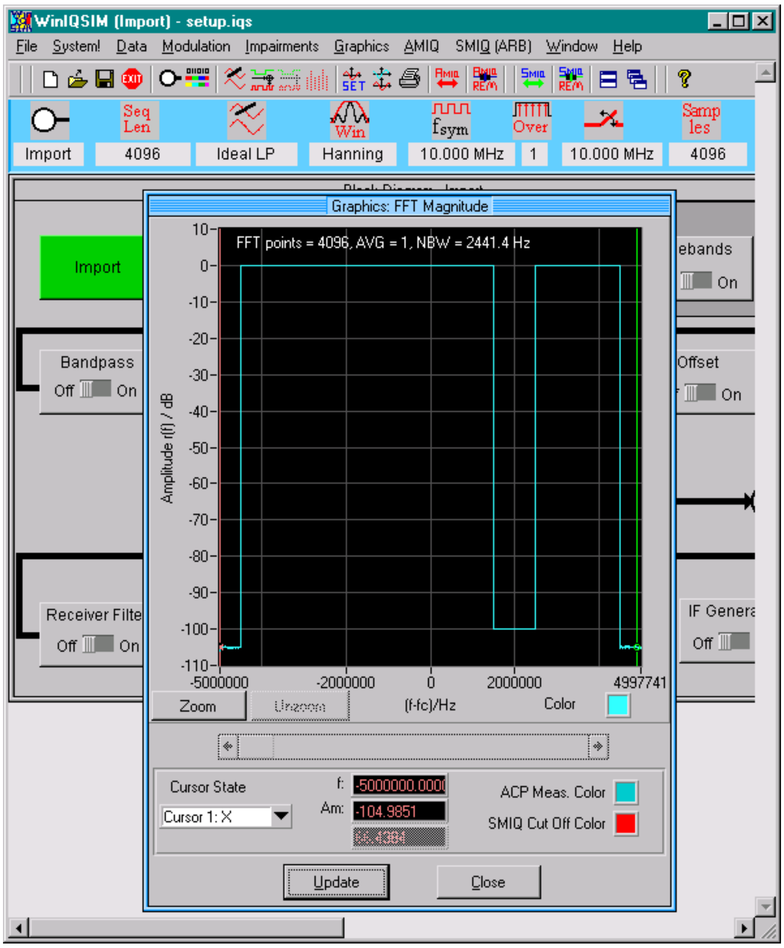

Fig. 6-38: WinIQSIM Microwave Example

FSx screenshot.

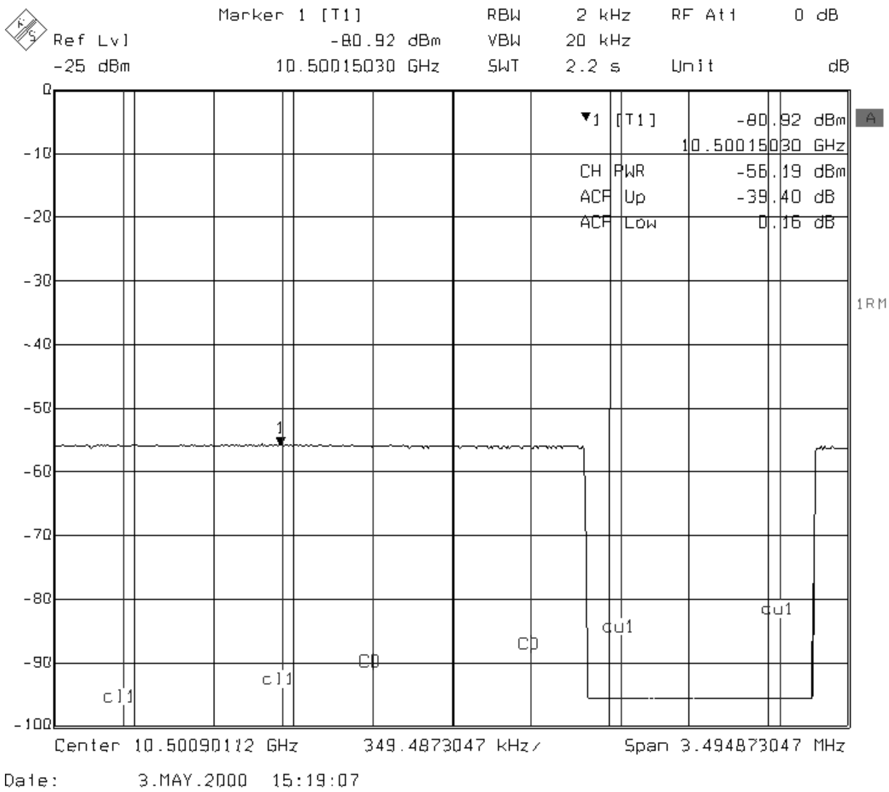

Fig. 6-39: FSx Microwave Example

7 Additional Information

Please contact **TM-APPLICATIONS@ROHDE-SCHWARZ.COM** for comments and further suggestions.

8 Ordering Information

Ordering Information		
Vector Signal Generator		
SMW200A	**Vector Signal Generator**	**1412.0000.02**
SMW-B10	Baseband Generator 64MS	1413.1200.02
SMW-B13	Baseband Main Module	1413.2807.02
SMJ100A	**Vector Signal Generator**	**1403.4507.02**
SMJ-B10	Baseband Generator 64MS	1403.8902.02
SMJ-B11	Baseband Generator 16MS	1403.9009.02
SMU-B13	Baseband Main Module	1403.9109.02
SMU200A	**Vector Signal Generator**	
SMBV100A	**Vector Signal Generator**	**1407.6004.02**
SMJ100A	**Vector Signal Generator**	**1403.4507.02**
SMV03	**Vector Signal Generator**	**1147.7509.13**
SFU	**Broadcast Test System**	**2110.2500.02**
IQ Modulator		
AFQ100A	**200 MHz Bandwidth**	**1401.3003.02**
AFQ100B	**528 MHz Bandwidth**	**1410.9000.02**
Spectrum Analyzer		
FSWxx	**(2 Hz to 67 GHz)**	**1312.8000.xx**
FSW-B17	Digital Baseband Interface	1313.0784.02
FSLx	**(9 kHz to 6 GHz)**	**1300.2502.xx**
FSVx	**(9 kHz to 7 GHz)**	**1307.9002.0x**
FSV-B70	Extension to 40MHz signal analysis bandwidth	1310.9645.02
EX-IQ-BOX	**Digital I/O Adapter**	**1409.5505.02**
Microwave Generator		
SMF100A	**(1 GHz to 43.5 GHz)**	**1167.0000.xx**

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