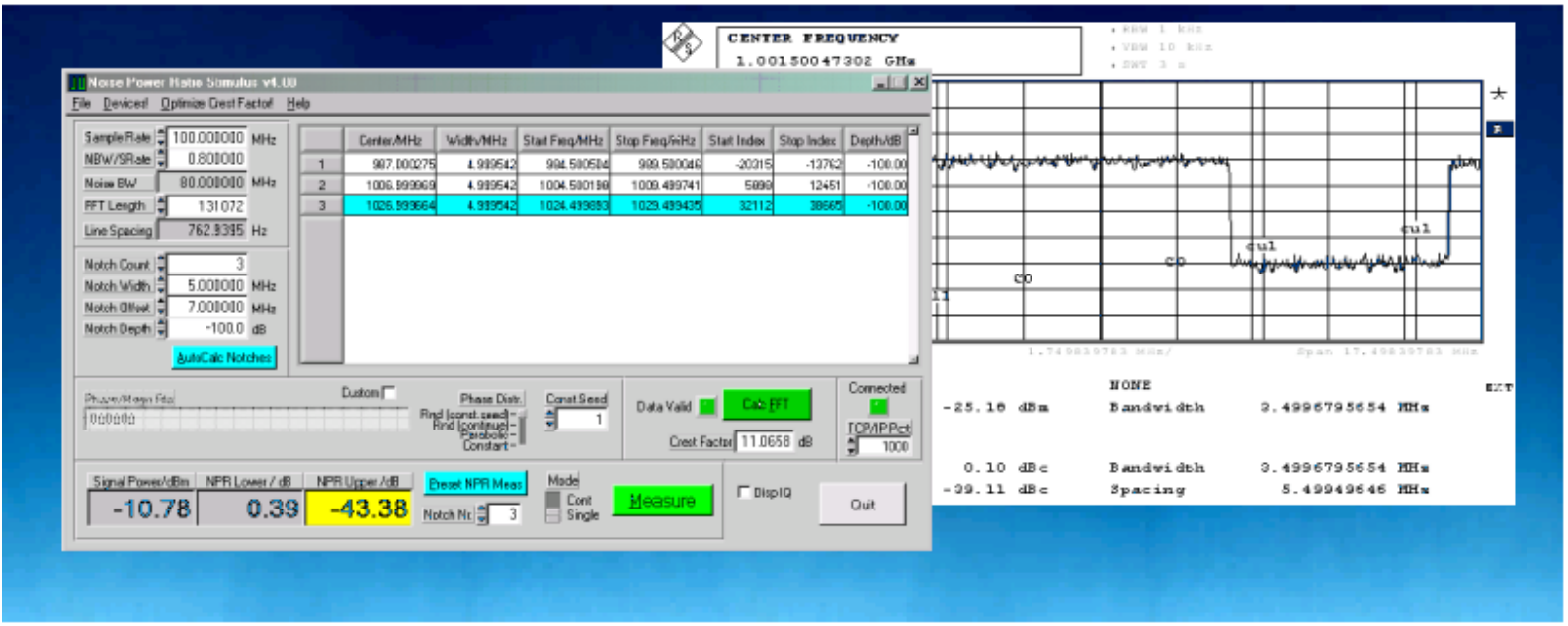

Products: AMIQ, SMIQ, SMR, FSEx, FSIQ, FSP, FSU

NPR - Noise Power Ratio Signal Generation and Measurement

Application Note

Noise Power Ratio (*NPR*) is an add-on tool for *WinIQSim* 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 the IEC/IEEE bus.

ROHDE&SCHWARZ

Contents

1 Overview

Noise Power Ratio *(NPR*) is an add-on tool for *WinIQSim* 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 IEC/IEEE bus. 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 particulary interesting for production specific applications.

2 Software Features

The software offers:

- custom notch definition
- generator and analyzer control
- load / save device configuration
- automatic measurement of specified notch with adjacent channel power (ACP) option

3 Hardware and Software Requirements

Hardware Requirements

The software runs on a PC with:

- CPU: 486, Pentium or better
- RAM: 64 MBytes or more
- Monitor: VGA color monitor
- IEC/IEEE bus: Rohde & Schwarz IEEE-488.2 bus interface ***PS-B4***, 1006.6207.04, or National Instruments ***AT-GPIB/TNT***

It requires the instruments named below:

- ***AMIQ***: I/Q modulation generator
- ***SMIQ***: Signal generator with I/Q inputs
- ***FSEx***, ***FSIQ***, ***FSP*** or ***FSU*** spectrum analyzer with ACP capability.
- ***SMR*** microwave generator is supported, but not mandatory.

Software Requirements

- ***Windows 95/98/NT4/2000***
- ***NI-488.2 v1.2*** (or higher) IEC/IEEE bus driver from National Instruments. See http://www.natinst.com for the latest revision.
- ***TCP/IP*** network protocol installed.
- ***WinIQSim v3.5*** (or higher) installed. This is a software tool that allows generates standard and custom I/Q signals e.g. for *ACP* measurements. It can download I/Q data to an *AMIQ* I/Q modulation generator and control an *SMIQ* generator. NPR communicates with WinIQSIM 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 v2.01*** (or higher) driver from National Instruments. See http://www.natinst.com for the latest revision.

4 Connecting the Computer and Instrument

Connect the computer running NPR to the instruments that are involved with the measurement, such as an AMIQ IQ modulator, an SMIQ IQ generator and an FSEx, FSIQ, FSP or FSU analyzer. Make sure that all instruments have a different IEC/IEEE bus address.

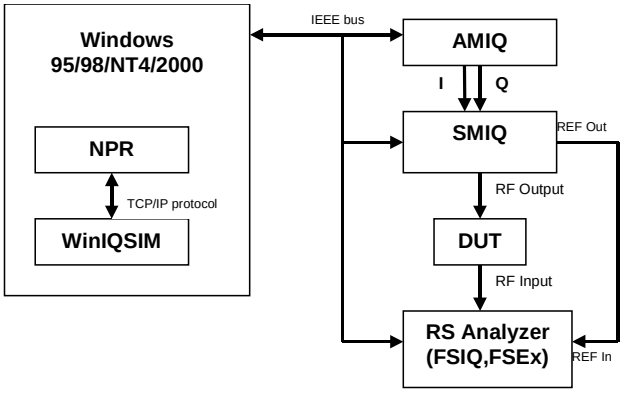

Fig. 1 Connecting Instruments

5 Installing NPR

Make sure you have **WINIQSIM** installed on your hard disc. For NPR installation you need the following files on floppy or hard disc:

Noise Power Ratio v3.xx.MSI	Win9x/NT/2000 installation file
DistFile.CAB	

Execute Noise **POWER RATIO V3.XX.MSI** and select the installation directory. A new menu item *Noise Power Ratio* will be created in *Start -> Program Files*. The installation directory will contain the files named below:

NPR.EXE	NPR executable
NPR.CFG	NPR configuration file
NPR.IQS	WinIQSIM configuration file
NPRPHMG.PMC	Custom phase / magnitude demonstration file
NPR.CHM	NPR online help manual
RsDevLib.DLL	R&S specific device library
RsFunLib.DLL	R&S function library

6 Starting the Software / Measurement

Execute **NPR.EXE**. The example setup below shows three notches generated with *AutoCalc Notches*. NPR configuration is stored in **NPR.CFG** at exit.

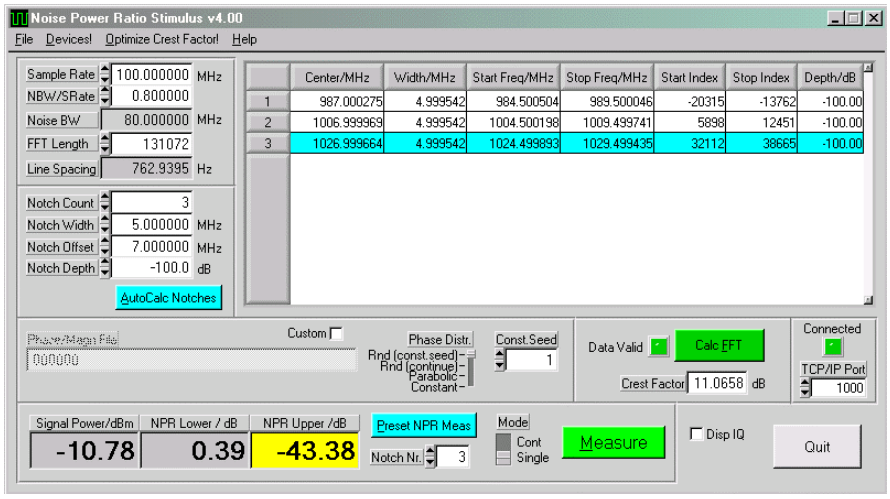

Fig. 2 Main Menu

Devices can be configured in the device menu. See **DEVICES** for details. Then 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 AMIQ via WinIQSIM (see following section, step 4) press the **PRESET NPR MEAS** button to put the analyzer in ACP measurement mode. Then select a **NOTCH NR** and press the **MEASURE** button to receive the signal's **NPR** and calculated **SIGNAL POWER**.

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

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

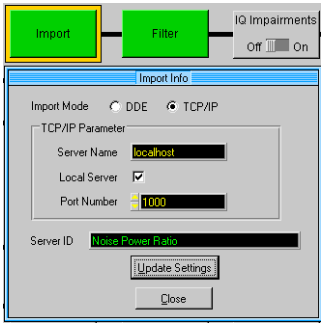

Fig. 3 WinIQSIM Import Settings

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

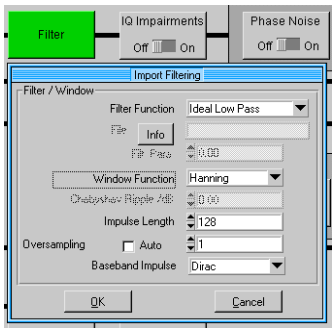

Fig. 4 WinIQSIM Filter Settings

3. GRAPHIC DISPLAY

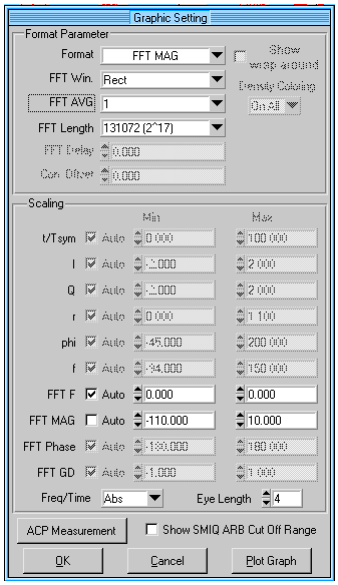

Fig. 5 WinIQSIM Graphic Setting

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

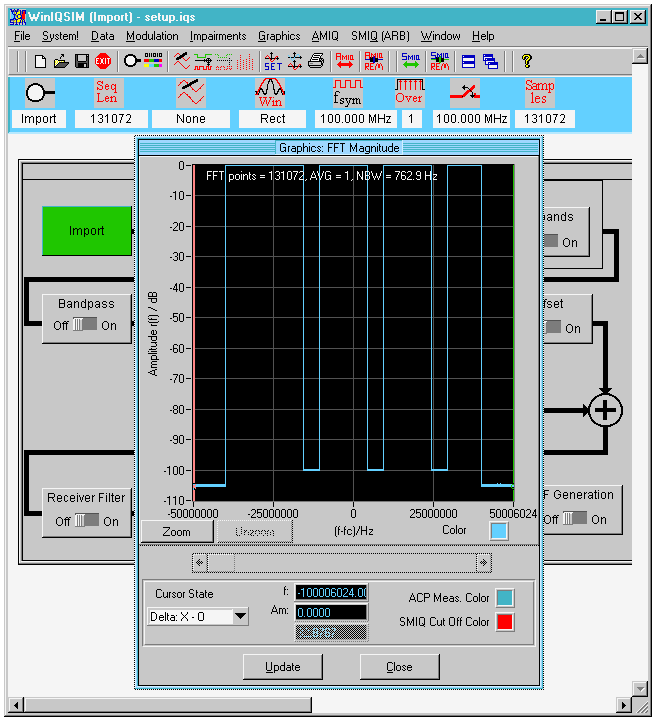

Fig. 6 WinIQSIM Graphic Display

4. To transfer the signal to the AMIQ press the WinIQSim menu item **AMIQ -> TRANSMISSION** or the short cut key **AMIQ <->**.

Fig. 7 WinIQSIM AMIQ Transmission

5. *NPR* can set up the analyzer for NPR 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*
Center 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.

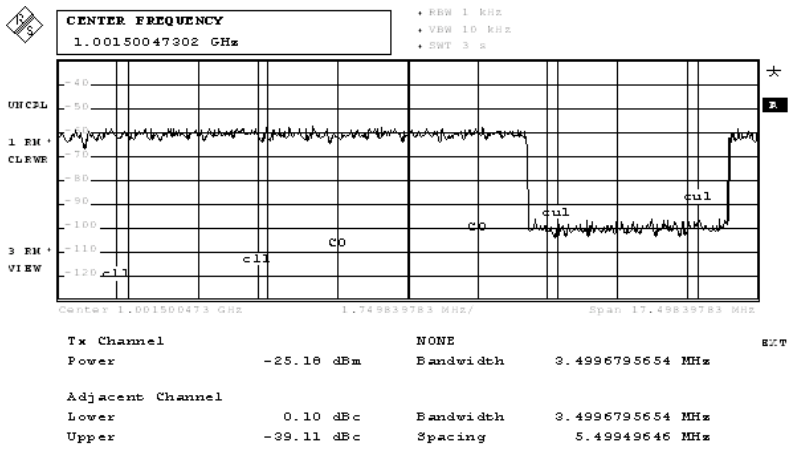

Fig. 8 FSP ACP Display

Parameters

Sampling Parameters

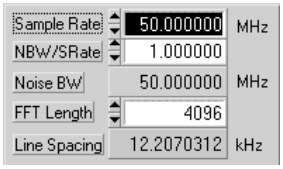

Fig. 9 Sampling Parameters

- **SAMPLE RATE** – Configures the AMIQ D/A converter 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 - 105 MHz.
- **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.

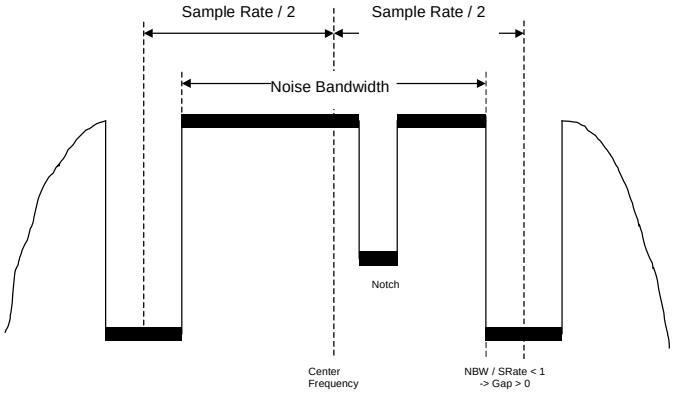

Fig. 10 Noise BW / Sample Rate

- **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.

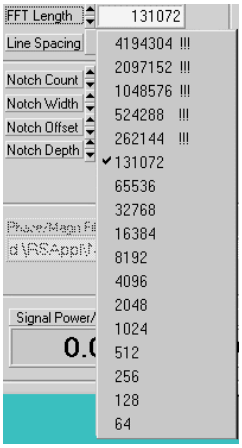

Fig. 11 FFT Length

FFT lengths greater than 128kS are marked with an exclamation mark to indicate that the Calc FFT function takes unproportionally long in case memory runs out and Windows uses the memory swapping option. The latest WinIQSIM revision 3.5 can only display FFT lengths up to 128kS correctly. An FFT length of 4MS requires an AMIQ 04. Following warning occurs when decreasing the FFT length:

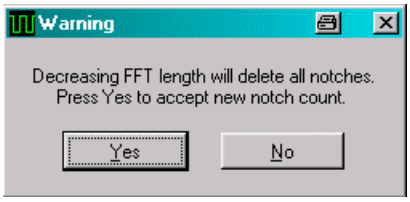

Fig. 12 FFT Length Warning

No changes take place after pressing **NO**. After pressing **YES** all the notches defined previously are deleted. This step is necessary because a smaller FFT length decreases resolution and can leads to an erratic notch list display.

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

  Line Spacing = Sample Rate / FFT Length

Notch Related Parameters

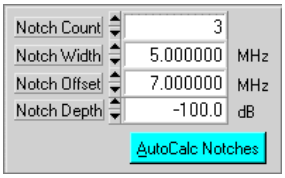

Fig. 13 NPR Notch Related Parameters

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

  Notch Count $\leq$ *NBW / 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*".

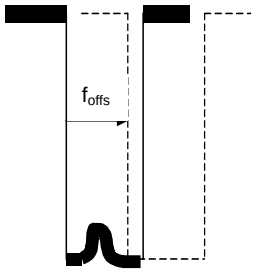

Fig. 14 NPR Notch Offset

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

Phase / Magnitude Distribution

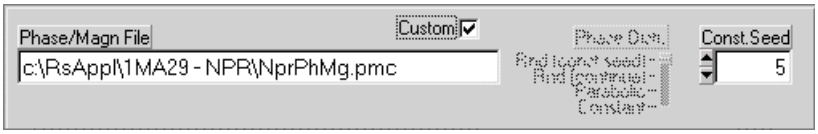

Fig. 15 Phase / Magnitude Distribution

- **PHASE DISTRIBUTION**
  - **RANDOM (CONST. SEED)** – I/Q-phase arrays are filled with random values between -π and +π. 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 -π to +π. 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.
- **CUSTOM** – Loads a custom phase / magnitude configuration (*.pmc) file. After loading the **.pmc* 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 -3.145e0 0.95

		magnitude (range 0 to 1.0)
	phase offset (range ±π)	
index nr (range 0 to element count)		

  .....

  4095 2.4567e0 0.34

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	987.000275	4.999542	984.500504	989.500046	-20315	-13762	-100.00
2	1006.999969	4.999542	1004.500198	1009.499741	5898	12451	-100.00
3	1026.999664	4.999542	1024.499893	1029.499435	32112	38665	-100.00

Fig. 16 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 ≤ f_{center} ≤ $f_{carrier}$ + 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 theactual signal is limited to > -70dB by the AMIQ.*

Calculate FFT

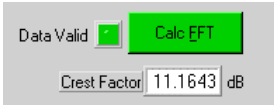

Fig. 17 Calculate FFT

- Press the Calc FFT button to calculate the NPR signal in WinIQSIM complient 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.

Connected

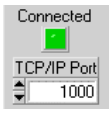

Fig. 18 TCP/IP Connection Status

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

Menu

Load / Save Configuration File

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

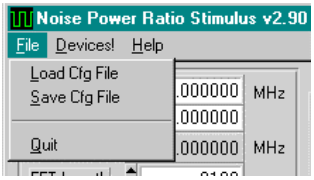

Fig. 19 File Menu

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

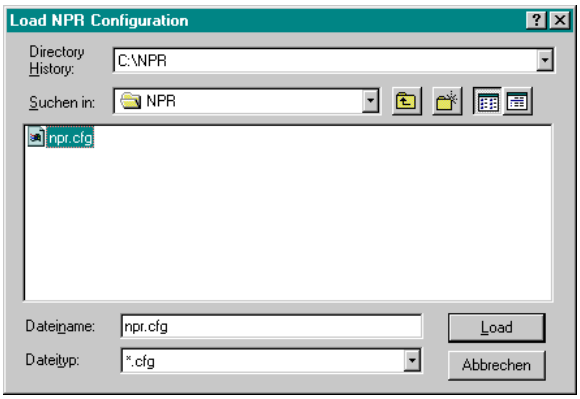

Fig. 20 Load Configuration

- **SAVE CONFIGURATION** – the default vfile extension is **.cfg*.

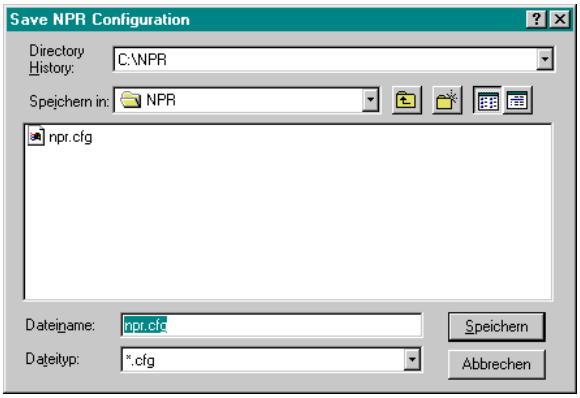

Fig. 21 Save Configuration

Devices

Custom configure a generator, an analyzer or a microwave generator hooked up to the GPIB bus.

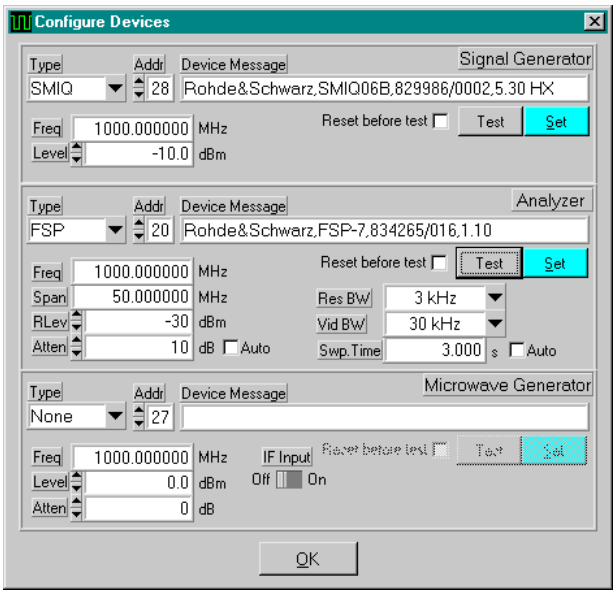

Fig. 22 Device Configuration

- **SIGNAL GENERATOR**

TYPE	SMHU58, SMIQ
ADDR	Range 1...31
RESET	Resets generator and returns device ID (**DEVICE MESSAGE**).
TEST	Checks if the generator is connected to GPIB bus and returns ID string.
SET	Configures the generator via GPIB bus with parameters namd below .
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, FSIQ, FSP, FSU
ADDR,RESET,TEST	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, *SMR*
ADDR,RESET,TEST	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.

Optimize Crest Factor

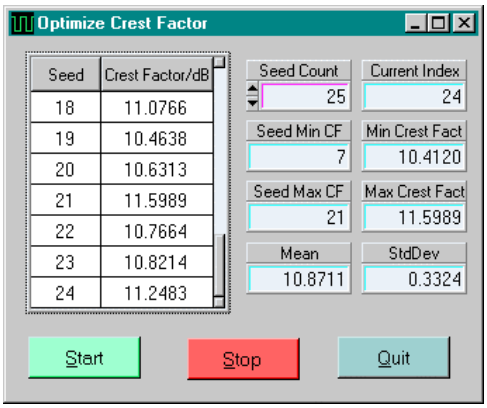

Fig. 23 Optimize Crest Factor

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**.

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 *FSEx, FSIQ, FSP* or FSU to obtain the noise power ratio of the notch.

Fig. 24 NPR Measurements

- **PRESET NPR MEAS** – 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.*

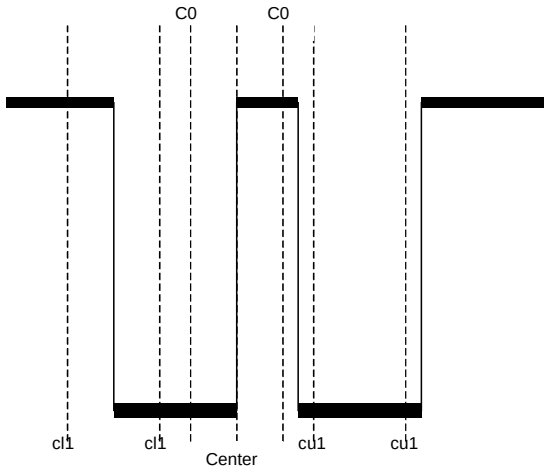

Fig. 25 Correct ACP Readout

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 AMIQ, SMIQ, SMR with a mixer option for signal generation and an FSE (FSP, FSIQ depending on maximum frequency) for signal analysis.

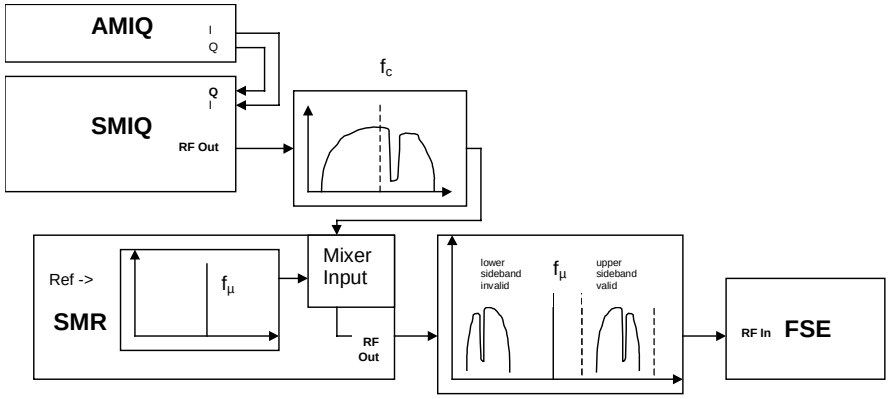

Fig. 26 NPR with Microwaves

The carrier frequency of the SMIQ (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 therefor not adequate for our purposes. Our example uses the following setup: fμ = 10GHz, fc = 500MHz. Note that the resolution bandwidth is set to < 2kHz and the sweep time is >2s. It is also possible to merge both signals via an external mixing component.

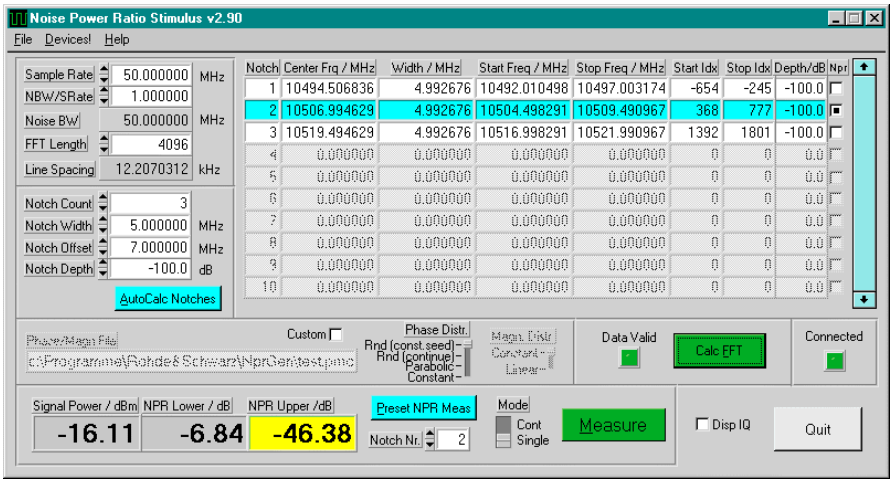

Fig. 27 NPR Microwave Example

WinIQSim graphic display.

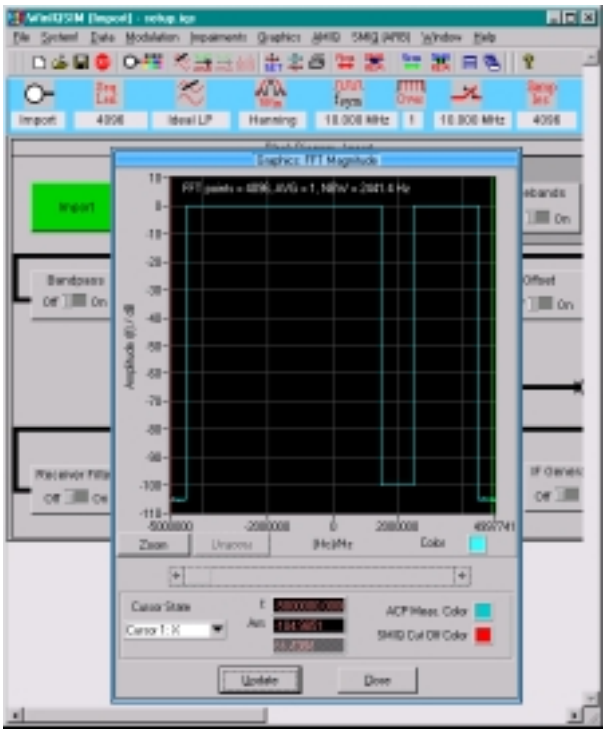

Fig. 28 WinIQSIM Microwave Example

FSE screenshot.

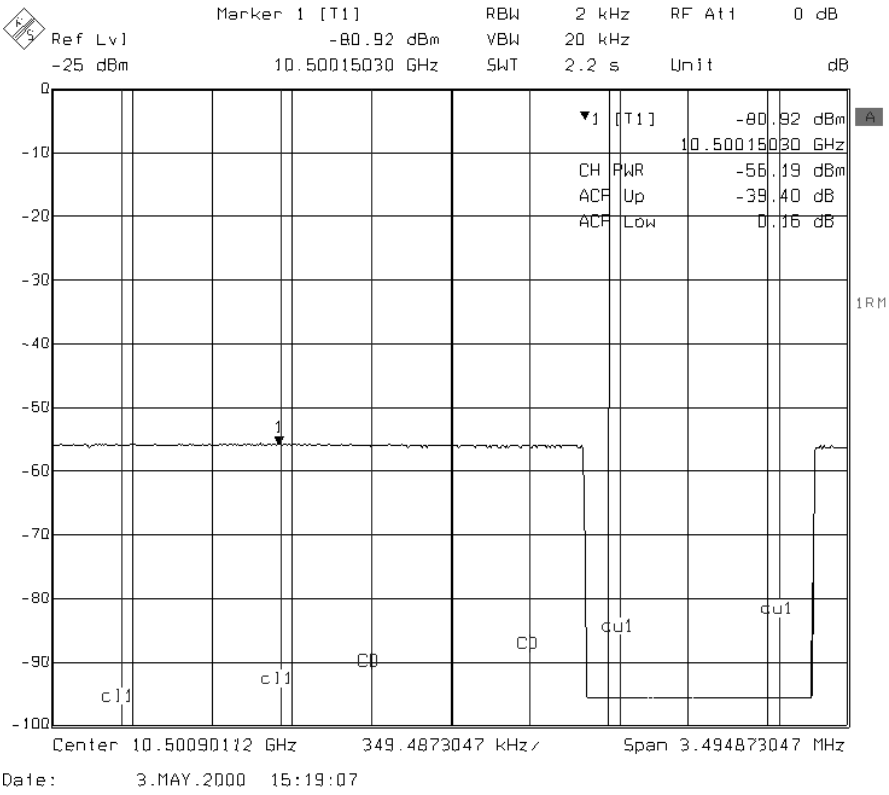

Fig. 29 FSE Microwave Example

7 Additional Information

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

8 Ordering information

IQ Modulator		
AMIQ-03	4 MSamples	1110.2003.03
AMIQ-04	16 MSamples	1110.2003.04
Vector Signal Generator		
SMIQ02	(300 kHz to 2.2 GHz)	1084.8004.02
SMIQ02E	(300 kHz to 2.2 GHz)	1106.1806.02
SMIQ03	(300 kHz to 3.3 GHz)	1084.8004.03
SMIQ03E	(300 kHz to 3.3 GHz)	1106.1806.03
SMIQ06	(300 kHz to 6.0 GHz)	1084.8004.06
Spectrum Analyzer		
FSEA20	(9 kHz to 3.5 GHz)	1065.6000.20
FSEA30	(20 Hz to 3.5 GHz)	1065.6000.30
FSEB20	(9 kHz to 7.0 GHz)	1066.3010.20
FSEB30	(20 Hz to 7.0 GHz)	1066.3010.30
FSEK20	(9 kHz to 40 GHz)	1088.1491.20
FSEK30	(20 Hz to 40 GHz)	1088.3494.30
FSEM20	(9 kHz to 26.5 GHz)	1080.1505.20
FSEM30	(20 Hz to 26.5 GHz)	1079.8500.30
FSIQ3	(20Hz to .3.5GHz)	1119.5005.03
FSIQ7	(20Hz to .7 GHz)	1119.5005.07
FSIQ26	(20Hz to .26 GHz)	1119.6001.26
FSP3	(9 kHz to 3 GHz)	1093.4495.03
FSP7	(9 kHz to 7 GHz)	1093.4495.07
FSP13	(9 kHz to 13 GHz)	1093.4495.13
FSP30	(9 kHz to 20 GHz)	1093.4495.30
FSU3	(20 Hz to 3.6 GHz)	1129.9003.03
FSU8	(20 Hz to 8 GHz)	1129.9003.08
Microwave Generator		
SMR20	(10 MHz to 20 GHz)	1104.0002.20
SMR27	(10 MHZ to 27 GHz)	1104.0002.27
SMR30	(10 MHz to 30 GHz)	1104.0002.30
SMR40	(10 MHz to 40 GHz)	1104.0002.40
SMR B23	IF-Input 20 GHz	1104.5804.02
SMR B24	IF-Input 40 GHz	1104.6100.02

ROHDE & SCHWARZ GmbH & Co. KG · Mühldorfstraße 15 · D-81671 München · P.O.B 80 14 69 · D-81614 München ·
Telephone +49 89 4129 -0 · Fax +49 89 4129 - 13777 · Internet: http://www.rohde-schwarz.com