



# Noise Figure Measurement Setup with VDI Noise Source and SAX Modules



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#### Introduction

This document provides information on how to make millimeter-wave Noise Figure and Gain measurements using a VDI Spectrum Analyzer Extension (SAX) Module and Noise Source.

For input power limitations, safety guidelines, general operating practices and recommendations for all equipment used in this measurement solution, please refer to the appropriate user manuals and/or datasheets.

This document is accurate as of June 1, 2021.

#### **Equipment Requirements**

The following equipment will be needed for this measurement solution:

- VDI Noise Source (WRX.xNS)
- VDI Spectrum Analyzer Extension Module (WRX.xSAX in Configuration C)
- Keysight Spectrum Analyzer (N90x0B with N9069M0E Noise Figure Measurement Application Option)
- Keysight Signal Generator (MXG or similar)\*
- PreAmplifier\*\*
- Waveguide Isolator†
- DUT (e.g. LNA Low Noise Amplifier)

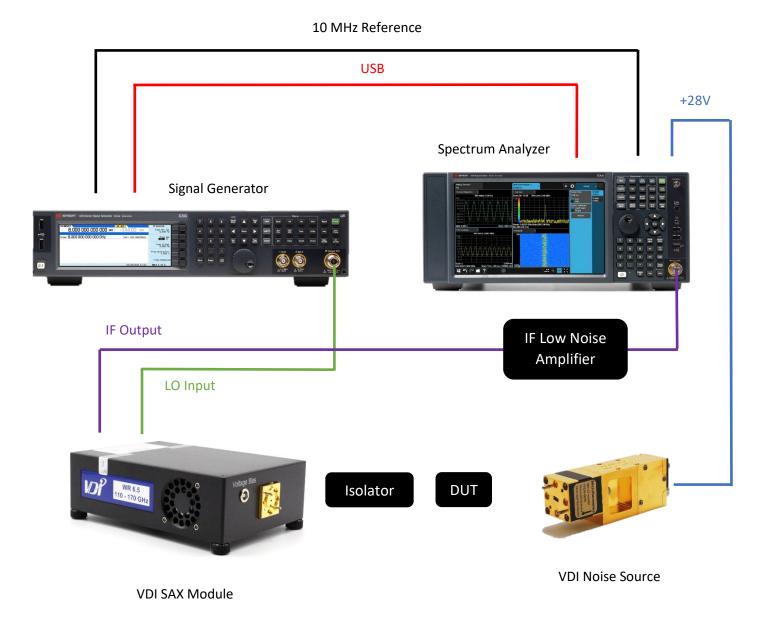
\*Other signal generators may be used, but will need to communicate and be controlled by the Keysight Spectrum Analyzer. The signal generator must be able to drive the LO Input Port of the VDI SAX Module across the required frequency range and power level.

\*\*Connected between the IF Output Port of the SAX and the RF Input Port of the Spectrum Analyzer. This may not be required for certain applications.

†VDI recommends the use of a waveguide isolator between the DUT output and the RF Input Port of VDI SAX Module to improve impedance match and reduce possible standing waves.



Typical block diagram for the Noise Figure Measurement setup is shown below.





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#### Generating ENR File Compatible with Spectrum Analyzer

ENR vs. Frequency data values can be entered manually using the "Edit Meas Table" menu item described in the "Verify ENR Table" section, later in this document.

Alternatively, you can upload a .csv file with ENR vs. Frequency data values (see example below for ENR file format). VDI Noise Sources will have an appropriately formatted ENR file included in the shipped documentation.

#### Sample ENR File Format

Comments shown in red. Red text is not included on the .csv file.

```
[Filetype ENR],
[Version A.27.05], Instrument (Spectrum Analyzer) Software Revision Number*
[Serialnumber b1-05], Noise Source Serial Number
[Model vdi6.5ns_r1], Noise Source Model Number
1.09995E+11,11.02815447
1.10995E+11,11.02815447
1.11995E+11,11.17974241
1.11995E+11,11.08859996
1.13995E+11,11.08859996
1.13995E+11,10.90244843
1.14995E+11,11.08731449
```

\*Software Revision Number on the file provided by VDI will default to A.27.05. But should be reviewed and adjusted by the user if they use a different SA or revision number.

#### Load ENR .csv File onto Spectrum Analyzer

- Load ENR File onto a USB Drive
- Connect USB Drive to Spectrum Analyzer
- Press [Recall] soft key



- Click on 'ENR Table' on the list of menu options (left column).
- Click on 'Meas (Common) Table'
- Click on 'Recall From'
- Navigate to and Click on the ENR .csv file you want to upload
- Click on 'Recall'



## Spectrum Analyzer Setup

#### **Verify Hardware Configuration**

-

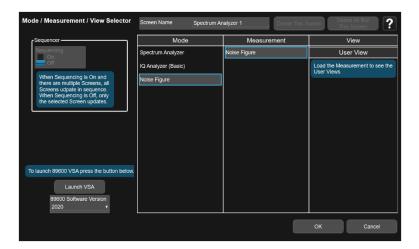
Verify hardware connections, as shown on Page 4 of this document.

#### Software Configuration and Setup

- Press [Mode/Meas] soft key



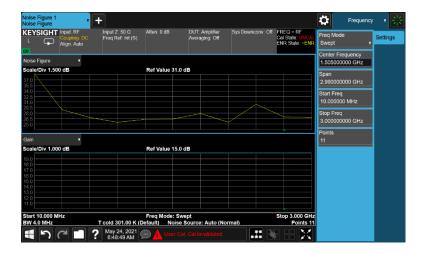
- Default Mode should be set to 'Spectrum Analyzer'
- Set to 'Noise Figure'
- Press 'OK'





# Spectrum Analyzer Setup - continued

- After pressing 'OK', you should see the following screen (showing Noise Figure and Gain plots)



- Press [Meas Setup] soft key



- Click on 'Ext LO Setup'





## **Spectrum Analyzer Setup - continued**

- Click on 'Sys Downconv LO Setup'

	Ext LO Setup		って? Close〉
DUT LO	Sys Do	ownconverter LO	
	On	On and a second	
Ext LO Control		D Control Off	
DUT LO Setup		Sys Downconv LO Setup 💙	
DUT LO		None	
Sys Downconv LO		:2391::7937::MY59101060::0::INS	TR
	LO Select	$\rightarrow$	

- Enter appropriate settings for the LO Signal Generator (See Example below)
- Click 'Close' when complete

Ext LO Setup		Sys [	Downconv LO Setup	ත (~ ? Close
O Settings		LO Commands		
LO Power	4.00 dBm	Command Set	SCPI Custom	
Settling Time	100 ms	Power Prefix	POW	
Multiplier Numerator	1	Power Suffix	DBM	
Multiplier Denominator	6	Freq Prefix	FREQ	
Min Freq	9.00000000 kHz	Freq Suffix	HZ	
Max Freq	40.0000000 GHz	Auxillary	OUTP:STAT ON	

#### Example System Down-Converter LO Setup

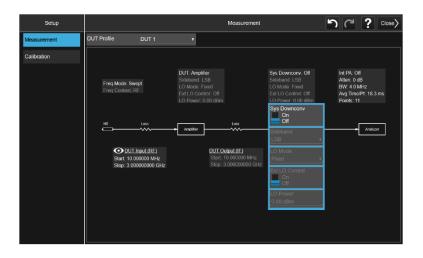
- LO Power: 4dBm [This sets the output power from the external signal generator]
  - This may depend on system down-converter LO input power specifications. Set LO power appropriately based on system down-converter module.
- Settling Time: 100ms (Default, can be adjusted if needed)
- Multiplier Numerator: 1
- Multiplier Denominator: 6 [Set by the LO Harmonic Factor of the system down-converter]
- Min Freq: 9kHz [Default, Based on your Signal Generator]
- Max Freq: 40 GHz [Default, Based on your Signal Generator]



- Click on 'DUT Setup & Calibration'



- Click on 'Sys Downconv' drop down menu and turn it on.

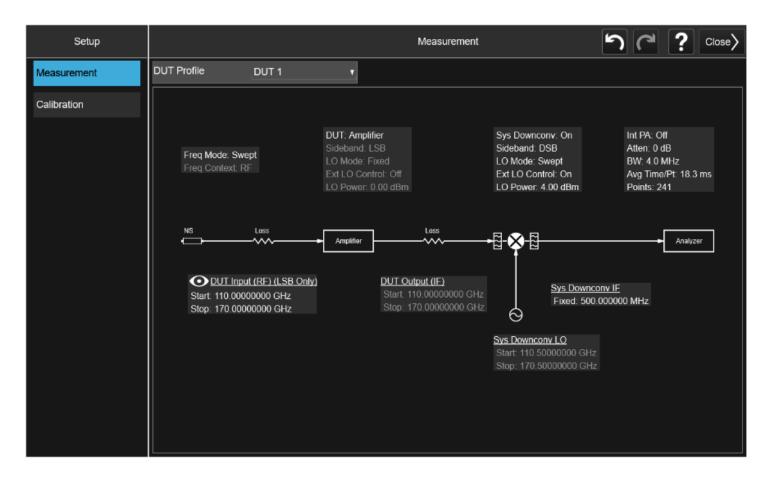


- Set parameters as shown below:
  - Sys Downconv: ON
  - o Sideband: DSB
  - o LO Mode: Swept
  - Ext LO Control: ON
  - o LO Power: 4dBm [Set based on previous LO Signal Generator settings in System Down-Converter LO Setup]



## **Spectrum Analyzer Setup - continued**

- Set remaining system parameters based on your system requirements.
- Example shown below to measure waveguide low noise amplifiers across 110-170 GHz using a WR6.5NS and a WR6.5SAX
- Click 'Close' when complete.





## Verify ENR Table

Verify ENR Table has loaded correctly

- Click on 'ENR'

Noise Figure 1 Noise Figure	· +				Meas Setu	• <b>•</b> ₩
L Coupling: DC Align: Auto	Input Z: 50 Ω Freq Ref: Int (S)	Atten: 0 dB	DUT: Amplifier Averaging: Off	FREQ = RF Cal State: UNCAL ENR State: ~ENR		Settings Cal Setup
Noise Figure 🔻					Averaging On	
Scale/Div 1.500 dB		Ref Value 30.	0 dB		DUT Profile	Noise Source
36.0					DUT 1 T	Loss Comp
33.0 31.5 30.0 28.5 27.0					Calibration	Limits
25.5					K Ext LO Setup	Advanced
24.0					Calculator	
Gain v Scale/Div 1.000 dB		Ref Value 15.	0 dB		Optimize Preselector	
19.0					Meas Preset	
17.0 16.0 15.0 14.0					CALIBRATE	
13.0						
12.0						
Start 10.000 MHz BW 4.0 MHz	T cold 301.00 K (E	Freq Mode: S Default) Nois	wept e Source: Auto (Norm	Stop 3.000 GHz Points 11		
	May 24, 2021 6:53:01 AM					

- Verify that ENR Mode is set to 'Table' not 'Spot
- o 'Spot' can be used if user wants to set a flat, fixed ENR value across the full band
- Click on 'Edit Meas Table' to verify that the ENR data has loaded correctly
- Click 'Close' after ENR data has been verified

			ENR		
ENR		_			
ENR Mode	Table Spot				
Table ENR			Spot ENR		
Use Meas Table Data for Cal	On Off		Spot Mode	ENR T Hot	
Edit Meas Table	$\rangle$	K			
Edit Cal Table	$\rightarrow$		Spot T Hot	9892.80 K	
T cold			User T cold		
User	User T cold	301.00 K	From SNS		
Default (301.00 K)	SNS T cold	301.00 K Off			



## Calibration

- Connect equipment as shown on Page 4, without the DUT (i.e. connect VDI Noise Source directly to VDI SAX Module Additional waveguide sections may be needed for proper waveguide flange connections)
- Click 'Calibrate'
  - $\circ$   $\,$  Can be a slow sweep, depending on sweep parameters
- After Calibration procedure is complete, Noise Figure and Gain plots should be close to 0dB, as shown below.





#### Measurement

- Once Calibration procedure is complete, disconnect the VDI Noise Source and the VDI SAX.
- Connect DUT between the VDI Noise Source and VDI SAX Module (as shown on Page 4).
- Apply Voltage Biases to DUT, as needed.
- Example plot of VDI WR8.0AMP-LN is shown below

Noise Figure 1 Noise Figure	,	+						Meas Setup	• ▼ ₩
	Input: RF Coupling: DC Align: Auto	Input Ζ: 50 Ω Freq Ref: Int (S)	Atten: 0 dB	DUT: Amplifier Averaging: Off	Sys Downconv: DSB IF: 500.00000 MHz	FREQ = RF Cal State: CAL ENR State: ~ENR	Avg/⊦ 10	lold Num	Settings
Lo Noise Figure	▼						Avera	aging On	Cal Setup
Scale/Div 3.00	0 dB		Ref Value 16.0 dl	В				Off	Noise Source
28.0 25.0 22.0 19.0								Profile 1 ▼	Loss Comp
19.0 16.0 13.0					~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~		ζ [	DUT Setup & Calibration	Limits
10.0 7.00 4.00				~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~				Ext LO Setup	Advanced
¥	<u> </u>						<	Uncertainty Calculator	
Gain Scale/Div 7.00	• 0 dB		Ref Value -1.0 dl	В				Optimize Preselector	
27.0								Meas Preset	
13.0 6.00 -1.00								CALIBRATE	
-8.00							<	ENR	
-22.0 -29.0		_							
Start 110.000 C BW 4.0 MHz	SHz	T cold 301.00 K (D	Freq Mode: Swe efault) Noise S	pt ource: Auto (Nori		op 170.000 GHz Points 241			
		<b>?</b> May 24, 2021 8:51:56 AM	Calibration	n; ENR table extra	polater				

