Application Note



Noise Figure Measurement Methods

MS269xA-017/MS2830A-017/MS2840A-017

Noise Figure Measurement Function

Contents

1. Introduction	3
2. Basics of Noise Figure (NF)	
2.1. What is Noise Figure :	
2.3. Noise Figure Measurement Methods	6
3. Measuring NF using Spectrum Analyzer (Amplifier Mode)	8
3.1. NF Measurement and Principles using Y Factor Method	8
4. Measuring NF using Spectrum Analyzer (Converter Mode)	
4.1. NF Measurement with Frequency Converter	
4.2. Measurement Investigation	
4.3. NF Measurement Procedure in Converter Mode	21
5. Other Measurement Precautions	
6. Uncertainty of NF Measurement Methods	
7. Summary	

1. Introduction

Against the background of the switchover to digital TV broadcasting, the increasing number of TV channels and the expanding market for duplex video communications (Video on Demand) are driving an increase in the number of broadcast satellites. Therefore, it is increasing the demand for Low Noise Block Down Converters (LNB) for receiving video transmissions from these satellites.

The signal-to-noise ratio (SNR) at the input of a radio receiver is a key parameter of communication systems. Because the transmission power that reaches the receiver is low, to reduce the Noise Figure (NF) in the satellite communication systems is especially important.

The LNB contains a Low Noise Amplifier (LNA) that corrects for the conversion losses of down converter and the transmission power that reaches the receiver, so measurement of the NF is a key item at every stage from design through mass production.

The measurement item of LNB is the 3rd order Intercept Point (IP3) as well as NF and conversion gain. There is a scene that uses the spectrum analyzer. It is advantage that spurious and IP3 and NF measurement can be covered using one spectrum analyzer.

This application note explains the basics of NF measurement as well as NF measurement methods using a spectrum analyzer.

The explanation is the divided into amplifier mode and converter mode. The amplifier mode is for measurement amplifier such as LNA. The converter mode is for measurement mixer and LNB.

In addition, it also explains precautions for evaluating an actual device under test (DUT).

2. Basics of Noise Figure (NF)

2.1. What is Noise Figure?

This section explains the noise figure (*NF*) by quantifying the noise in an amplifier.

In a linear amplifier, the ratio of the signal to the noise (*SNR*) is expressed by an index called the Noise Figure (*NF*). It is defined as the ratio of *SNR_out* (output signal noise ratio) to *SNR_in* (input SNR), and although it may be expressed differently according to the literature, in most cases, this ratio is called *F* (Noise Factor).

$$SNR = \frac{Signal_Level[mW]}{Noise_Level[mW]} \quad (SNR_dB = Signal_Level[dBm] - Noise_Level[dBm]) \qquad ...(1)$$

$$F = \frac{SNR_in}{SNR_out} = \frac{\frac{S_in}{N_in}}{\frac{S_out}{N_out}} \qquad ...(2)$$

The value of *F* expressed in dB is called the Noise Factor and is defined by the following equation.

$$NF = 10 \times Log(F) \tag{3}$$

For a better understanding of this equation, we need to consider a theoretical amplifier without noise. In this circumstance, since the *SNR* does not change at the amplifier input and output, it is clear that F = 1, and NF = 0 [dB]. When using a semiconductor device linear amplifier and considering the *SNR* of the input signal (*SNR_in*), clearly the output of the amplifier after multiplication by the gain (*G*) is *S_out* = *G* x *S_in*, and the output multiplied by the gain (*G*) is *N_out* = *G* x *N_in* relative to Nin, but, actually it is output with some fixed noise power added (*N_add*).

This relationship is expressed by the following equation.

$$Sout = G \times S _ in$$

$$Nout = Nadd + G \times N _ in$$
...(4)

Substituting Eq. (4) into Eq. (2), gives the equation for the Noise Factor (F):

$$\mathbf{F} = \frac{Nadd + G \times Nin}{G \times Nin} \tag{5}$$

Figure 2-1 illustrates Eq. (5) as a graph. The important point to draw from this is that Nadd and Gain can be found from the measurement results for any two points.



2.2. Noise Figure at Multistage Connection

This section explains the Noise Figure when active devices such as amplifiers that add noise are connected in a cascade.

First, consider the amplifiers connected in several stages as shown below:



Fig. 2-2. NF Outline at Multistage Connection

From this equation, the value of *F* for the entire system can be defined by the following equation.

$$F_{t} = F1 + \frac{F2 - 1}{Gain_{1}} \qquad ...(6)$$

$$F_{t} = F1 + \frac{F2 - 1}{Gain_{1}} + \frac{F3 - 1}{Gain_{1} \times Gain_{2}} + ... + \frac{Fn - 1}{Gain_{1} \times Gain_{2} \times ... \times Gain_{n}} \qquad ...(7)$$

From Eq. (7), the value of F(NF) for the entire system has a smaller impact in the latter stages when using an amp with a large gain and smaller F(NF) is the first stage. This is the basic principle of a preamplifier used in a spectrum analyzer.

*Role of Preamplifier in Spectrum Amplifier

In a spectrum analyzer, a low-noise amplifier (LNA) is used at the stage before the 1st Mixer as a method to improve the Displayed Average Noise Level (DANL) of the spectrum analyzer. This LNA is called the preamp. According to Eq. (7), the preamp is most effective when it is positioned at front-most block and the most effective way of improving the spectrum analyzer DANL is simply to attach the preamp to the spectrum analyzer input terminal. When measuring low power levels like at NF measurement, it is best to use an internal preamp to achieve low spectrum analyzer DANL.

Additionally, attaching another external preamp to the RF input of the spectrum analyzer can improve the DANL even further.

2.3. Noise Figure Measurement Methods

2.3.1. Direct Method

In the direct method, a spectrum analyzer is used to measure the absolute power of the noise and the *NF* is calculated from this value. The advantage of this method is the simple system configuration, but the disadvantage is the need for a high-performance measuring instrument.

The following shows and explains some concrete measurement examples.

(1) Measuring amp with 10 dB gain and 3 dB *NF* using spectrum analyzer with –141 dBm/Hz DANL -141 dBm/Hz+10×(-174 dBm/Hz+3 dB) = -140.96 dBm/Hz ...(8)

 \rightarrow A level change of about 0.04 dB compared to the DANL when the spectrum analyzer is terminated can be monitored.

(2) Measuring amp with 10 dB gain and 3 dB NF using spectrum analyzer with -161 dBm/Hz DANL $-161dBm/Hz + 10 \times (-174dBm/Hz + 3dB) = -158dBm/Hz$...(9)

 \rightarrow A level change of about 3.0 dB compared to the DANL when the spectrum analyzer is terminated can be monitored.

First, in example (1), a level difference of 0.04 dB is captured and the DUT *NF* is found to be about 3 dB. When the power measurement accuracy of the measuring instruments is ± 0.01 dB at this time, the uncertainty of the calculated *NF* value is ± 0.9 dB / -1.4 dB.

On the other hand, in example (2), a level difference of 3.0 dB is captured, and although the DUT *NF* is found to be about 3 dB, in example (1), when the power measurement accuracy is ± 0.01 dB, the uncertainty of the calculated NF value is ± 0.04 dB / -0.04 dB.

In this measurement method, the uncertainty of the calculated *NF* value can be very different depending on the measured noise level, so a high-performance measuring instrument is required for measuring small *NF* values.

*–174 dBm is the thermal noise level at room temperature. It is called kTB noise and is calculated from the following equations at 27°C (300K).

$$k \times T \times B = 1.38 \times 10^{-23} \times 300 \times 1 = 4.14 \times 10^{-21} [W/Hz]$$

10×Log{4.14×10⁻²¹×10³[mW/Hz]} = -173.82[dBm/Hz]

To simplify Eq. 8 and Eq. 9, a value of –174 dBm/Hz is used.

k: Boltzmann Constant $[1.38 \times 10^{-23}]$

T: Absolute Temperature [K]

B: Bandwidth [Hz]

...(10)

2.3.2. Y Factor Method

In this method, two signals with different levels are input to the DUT and the *NF* of the DUT is calculated by comparing the *SNR* of the inputs and outputs for the two signals.

The Y factor method is a parameter expressing the ratio of the two level conditions defined as follows:

$$Y = \frac{Nout _ 2}{Nout _ 1} = \frac{Nadd + G \times Nin _ 2}{Nadd + G \times Nin _ 1}$$
...(11)

$$F = \frac{Nin _ 2 / Nin _ 1}{Y - 1} \tag{12}$$

$$F = \frac{ENR}{Y - 1} \tag{13}$$

In general, a noise source that accurately defines the ratio between the noise levels is used to generate N_{in_1} and N_{in_2} .

The ratio between these noise levels is called the Excess Noise Ratio (ENR) and is provided as calibration figures.

$$ENR _ dB = (NoiseSource _ on[dBm]) - (NoiseSource _ off [dBm])$$
$$ENR _ Linear = \frac{NoiseSource _ on[mW]}{NoiseSource _ off [mW]}$$
...(14)

3. Measuring NF using Spectrum Analyzer (Amplifier Mode)

3.1. NF Measurement and Principles using Y Factor Method

This chapter explains NF measurement using the Y factor method. There are 3 steps as the NF measurement.

- Setting: Frequency setting, ENR table setting, analysis time setting, etc.
 - Calibration: Measurement NF of the measurement system (NF_2) using Y factor method, and then it normalizes NF and conversion gain.
 - Measurement: measurement total NF (DUT + measurement system) using Y factor method, and then it calculates the NF of the DUT (NF_1) using Eq. (7).

It explains the detailed instructions below.

1) Calibrate the measurement system.

This calibration connects the noise source directly to the spectrum analyzer input and performs measurement using the Y factor method to calculate the NF of the measurement system (spectrum analyzer).

Figure 3-1 shows the measurement setup for calibration. At calibration, the noise source connector on the back panel of the spectrum analyzer and the noise source power terminal are connected, and the noise source output is connected directly to the spectrum analyzer.

Additionally, DC voltage is sometimes output, depending on the noise source. When using this type of noise source, as shown in Figure 3-2, attach a DC block to the spectrum analyzer input and connect the noise source to the block. (Refer to section 5 for noise sources with DC output.)

Calibration



Fig. 3-1. Measurement Setup at Calibration (when DC Block Not Required)



Fig. 3-2. Measurement Setup at Calibration (when DC Block Required)

2) Set the measurement conditions.First, set the parameters for the noise source.Refer to ENR values calibrated by noise source and set the ENR as shown in Figs. 3-3 to 3-5.Also, create an ENR table like that shown in Fig. 3-6 for each noise source.

[Procedure] Set the ENR value by recalling file

- 1. Press [Common Setting].
- 2. Press [ENR].
- 3. Press [Meas Table].
- 4. Press [Recall Meas Table].
- 5. Select the file from the list.

∕ MS2	830A Noise F	igure					10/29/2012 11:36:10	
вw		4 000 000Hz	ATT	0dB	Loss Status	Before:Off	🛗 Noise Figure 🛛 🚯	
Start F	requency	10 000 000Hz	DUT	Amplifier		After:Off	Common Setting	
Stop F	requency	3 600 000 000Hz	T cold	296.50K	CAI Status	ок	DUT Mode	
Total F	Point	11			ENR Status	Table	DOT MOUD	
Result					Average	5/5	Amplifier	
Ret	ference	4.00 dB 2.000 dB/div	Noise F	igure				
	12.00							
	10.00							
	8.00							
	6.00							
	4.00					<u> </u>		
	2.00							
	-200						10	
	-4.00						· ·	
							Loss Comp	
Ret	ference	15.00 dB 5.000 dB/div	Gai	n				ENR Setting Key
	35.00							
	30.00						ENR	
	25.00					<u> </u>		
	20.00							
	15.00							
	5.00							
	5.00							
	-5.00							
Fi	equency Min	10 000 00	00Hz	Frequency Max	3 600 00	00 000Hz		
	MKR	Fre	quency	Trace1 Levei	Trace2 Leve	1		
							4	
							Cal Setup	
Ref.Int	: Pre	e-Amp On					0	

Fig. 3-3. ENR setting display at calibration



Fig. 3-4. Recall display for ENR file

∧ MS2830A Noise Figu	re				_0	10/29/2012 11:36:37	
BW	4 000 000Hz	ATT	0dB	Loss Status	Before:Off	👫 Noise Figure	
Start Frequency	10 000 000Hz	DUT	Amplifier		After:Off	Select File	
Stop Frequency	3 600 000 000Hz	T cold	296.50K	CAL Status	ок		
Total Point	11			ENR Status	Table		
Result							
Refer Noise Figur	e					×	Select Recall file
Meas Table	List						
		<i></i>					
(D:) 50,54	1,556 Kbytes Free	/ 51,383,868 Kbyt	es Total				
Name			Date / Time	Size[By	tes] Protect		
Meas2012	20921_00		9/21/2012 9:15:44	AM	37 Off		
Meas2012	20921_01		9/21/2012 9:33:18 /	AM AM	325 Off		
Meas2012	21005 03		10/5/2012 11:04:29	AM	343 Off		
Meas201	21016 05		10/16/2012 4:32:24	PM	343 Off		
Meas2012	21011_04		10/17/2012 2:20:07	PM	178 Off		
					Close		
Frectaria frecta	10 000 0		i ioquotioy max			Set	
MKR	Fre	quency	Trace1 Level	Trace2 Lev	/el		
						Cancel	
Ref.Int Pre-Ar	mp On						

Fig. 3-5. ENR file selection display

How to edit the ENR file creates a new file by making a save once, and then edit the file.

Save directory \ANRITSU CORPORATION\SIGNAL ANALYZER\USER DATA\NF Data\ENR

Name of default file MeasYYYYMMDD_NN: YYYYMMDD is a date and NN is a suffix number.

[Procedure] Set the ENR value by recalling file

- 1. Press [Common Setting].
- 2. Press [ENR].
- 3. Press [Meas Table].
- 4. Press [Save Meas Table].
- 5. Open the file in the save directory.
- 6. Input the frequency and ENR value. The format is [Frequency,ENR value]. The unit of frequency is Hz.
- 7. Save the file.



Fig. 3-6. ENR file edit display

Next, set the measurement frequency range, number of measurement points, measurement bandwidth, analysis time and Storage On/Off (Fig. 3-7 and 3-8).

Lengthening the analysis time and setting the averaging processing with the Storage On/Off setting improves the measurement accuracy but there is a tradeoff in increased measurement time.



Fig. 3-7. Measurement frequency setting display



Fig. 3-8. Measurement condition setting display

This explains an example that the measurement accuracy is improved by increasing the analysis time. The following table shows the dispersion of measurement taken 10 times in the case that the analysis time are 300ms and 100ms. This is one of measurement example, this value is not guaranteed.

Analysis Time	dispersion of measurement taken 10 times
100ms	0.054dB
300ms	0.026dB

3) Execute calibration (obtaining NF of measurement system)

Calibrate by touching the [Calibration Now] key shown in Fig. 3-9.

Clicking the [Cancel] key shown in Fig. 3-10 stops calibration. (Calibration is completed when progress bar reaches 100%.)

[Procedure] Executes calibration.

- 1. Press [Common Setting].
- 2. Press [Cal Setup].
- 3. Press [Calibration Now]



Fig. 3-9. Calibration execution display



Fig. 3-10. Display during calibration

4) Perform measurement with the DUT connected.

The DUT is connected between the noise source and measurement system (spectrum analyzer) after calibration has been executed. The NF calculated at this step using the Y factor method is the total NF (DUT + measurement system).

Using the NF Measurement Function calculates the NF of the DUT (NF_1) from the NF measured with the DUT connected (NF_t) and the NF of the measurement system measured at calibration (NF_2) using Eq. (7), and shows calculating result in a table or graph.

DUT Setup



Fig. 3-11. Measurement system with the DUT connected (when DC block not required)



Fig. 3-12. Measurement system with the DUT connected (when DC block required)

Operate the Measure key to switch the display layout.

[Procedure]

Switch the display layout to the table from the graph.

- 1. Press [Measure].
- 2. Press [Layout].

⚠ MS2830A Noi	ise Figure								10/12/2012 14:19:19
BW	4	000 000Hz	ATT			0d	B Loss Status	Before:Off	🚻 Noise Figure 🛛 🜴
Start Frequency	/ 10	000 000Hz	DUT			Amplifie	r	After:Off	Gal Setup
Stop Frequency	3 600	000 000Hz	T cold			296.50	CAL Status	ок	Min ATT
Total Point		11					ENR Status	Table	dro.
Result									Uab
1.000 dB/div	Reference	4.00 dB	Ν	loise Fi	gure				Max ATT
8.00									2dB
7.00									
5.00									
4.00									
3.00									
1.00									
0.00									Apply Calibration
									0n 0ff
5.000 dB/div	Reference	15.00 dB		Gain					
35.00									
30.00									
25.00									
15.00									
10.00									Clear Cal Data
5.00									
-5.00									
Frequency	Min	10 000 00	00Hz		Fre	quency Max	3 600	000 000Hz	
M	KR	Fre	quency		Trace	e1 Level	Trace2 Le	vel	
									Galibration Now
Ref.Int	Pre-Amp On	1							

Fig. 3-13. Measurement result display (Graph)

▲ MS2830A Nois	se Figure						_0	10/12/	2012 1423	:18
BW Start Frequency	4 000 000Hz 1 010 000 000Hz	ATT DUT		0dB Amplifier	Loss Status	Befor	re:Off er:Off	Head Noise Trace	Figure	6
Stop Frequency	3 010 000 000Hz	T cold		296.50K	CAL Status		OK	Tra	ce Select	t
Total Point	21				ENR Status		Table	1	2	
Result					Average	10 <i>I</i>	10	<u> </u>	-	
	Frequency		Noise Figure		Gain			Re	sult Type	ų
1	010 000 000H	z	0.00505dB		0.002080	β	•		Gam	
1	110 000 000H	Z	0.00427dB		0.005550	B				
1	210 000 000H	z	0.03922dB		0.005460	B				
1	310 000 000H	z	0.01888dB		0.01007c	ΙB				
1	410 000 000H	z	0.02238dB		0.009460	IΒ				
1	510 000 000H	z	0.00502dB		0.00150	B				
1	610 000 000H	z	-0.00446dB		0.01100	B				
1	710 000 000H	z	-0.01116dB		0.000710	iΒ				
1	810 000 000H	7	-0.01241dB		0.01005	B				
1	910 000 000H	7	-0.02210dB		0.01146	B				
2	010 000 000H	7	-0 00156dB		0 001010	İB				
2		7	-0.001340dB		0.001010			Re	eference	
2	210 000 000H	7	0.02425dB		0.005210			1	5.00dB	
		-	0.0242548		0.000000		-		_	-
Frequency	Min 1 010 000 0	00Hz	Frequen	cv Max	3 010 00	0 000H	7	S	cale/Div	
linequency			riequen		001000			5	.000dB	
Ref.Int	Pre-Amp On									C

Fig. 3-14. Measurement result display (Table)

4. Measuring NF using Spectrum Analyzer (Converter Mode)

4.1. NF Measurement with Frequency Converter

Several connection examples are shown when measuring a frequency converter such as a mixer or a module incorporating a mixer.

When using Opt-020 or Opt-021 as Local Oscillator



Fig. 4-1. Example of Connections for Opt-020 or Opt-021

When Using External SG as Local Oscillator



Fig. 4-2. Example of Connections when Measuring DUT using External Signal Generator as Local Oscillator



When Using DUT with Built-in Local Oscillator, such as LNB (Low Noise Block Converter)

Fig. 4-3. Example of Connections when Measuring DUT with Built-in Local Oscillator

When the DUT is a frequency converter, there are some characteristics affecting NF measurement.



Fig. 4-4. Example of Connections for Opt-020 or Opt-021

RF...Between Noise Source and DUT; indicates input port to DUT

LO...Between DUT and Spectrum Analyzer; indicates output port from DUT

IF...Between Local Oscillator and DUT; indicates DUT LO signal input port from Local Oscillator

- Effect of Spurious such as Image Response
 With frequency converters, such as mixers, unexpected signals are generated by image responses, multiple responses, and IF feedthrough to become noise sources.
- Effect of Local Oscillator When noise in the local oscillator is converted by the mixer to IF bands it is added to the system NF. It changes according to the amount of noise in the local oscillator but is also affected by frequency-related noise such as image responses, multiple responses, etc.
- Effect of Local Oscillator Leaks
 If the mixer LO–IF isolation is low and there are LO components at the IF port, sometimes other spurious signals
 may be created.

The appropriate filters must be added to each port at measurement to eliminate concerns over these effects.

4.2. Measurement Investigation

The following four items have been selected to examine and measure the NF of a frequency converter using a MIXER as the DUT:

RF Frequency: 11 to 12 GHz LO Frequency: 10 GHz IF Frequency: 1 to 2 GHz

1. Select the DUT Mode.

This depends on whether the DUT is a frequency down or frequency up converter.

In the example, the down converter is selected because the frequency relationship is the IF < RF.

2. Select the LO Mode.

By selecting a fixed LO it is possible to investigate the IF frequency response of a DUT with changing IF. The RF frequency is calculated from the set LO and IF frequencies.

By selecting a variable LO it is possible to investigate the RF frequency response of a DUT with fixed IF. The LO frequency is calculated from the set RF frequency and IF frequency.

In the example, fixed LO is selected because the LO frequency is at one point.

3. Select the Side Band Mode.

A mixer with two responses (fLO+fIF, fLO-fIF) is called a Dual Side Band (DSB) mixer. Correspondingly, a mixer with a single side band is called a Single Side Band (SSB) mixer, while a mixer with only the upper side band (fLO+fIF) is called an Upper Side Band (USB) mixer and one with only the lower side band (fLO-fIF) is called a Low Side Band (LSB) mixer.

In the example, USB is selected because RF frequency is calculated as LO frequency + IF frequency.

4. With/Without Filter

A filter is inserted to suppress the effects of image responses, multiple responses, and IF feedthrough. In the example, either an 11-GHz HPF or a 11- to 12-GHz BPF is inserted to prevent generation of image responses, along with either a 2-GHz LPF or a 1- to 2-GHz BPF inserted at the IF port.

There are 10 permutations based on selections 1 to 3 and the following two pages introduce the setup diagrams.

Figure 4-5 shows the frequency relationship as an example.



Fig. 4-5. Frequency Relationship in Example

There are 10 possible permutations depending on the settings of the DUT Mode, LO Mode, and Side Band Mode. The following figures show the frequency relationship for each and the automatic computation equation.



DUT Mode: With Down Converter



Fig. 4-6. Combination in Down Converter Mode



Fig. 4-7. Combination in Up Converter Mode

4.3. NF Measurement Procedure in Converter Mode

There is difference part to select the DUT mode, but the measurement procedure of converter mode is the same as the amplifier mode.

1) Prepare for measurement.

Set the DUT mode as shown in Fig. 4-8 and 4-9 and then set the LO Mode and Side Band Mode.

Set either the Local Freq or IF Freq depending on the LO Mode setting.

When using a signal generator as the LO input to the DUT, set [LO Control] to On and then press the [LO Select] key to select the signal generator (Fig. 4-10).

When there is only one signal generator, the relevant name is displayed.

[Procedure]

Set the DUT mode, the LO Mode, and the Side Band Mode

- 1. Press [Common Setting].
- 2. Press [DUT Mode].
- 3. Select [Down Converter]
- 4. Press [Convert Setup]
- 5. Press [LO Mode]
- 6. Select [Fixed]
- 7. Press[LO Freq] and set the LO frequency to 8GHz.
- 8. Press [Side Band Mode]
- 9. Select [LSB]

↑ MS2830A Noise Fi	igure			_0	2/20/2014 13:39:36		
BW	4 000 000Hz	ATT	0dB	Loss Status	Before:Off	🏰 Noise Figure 🛛 👘	- DUT Made Catting Kay
Start Frequency	100 000 000Hz	DUT	Down Convertor		After:Off	Common Setting	
Stop Frequency	3 600 000 000Hz	T cold	296.50K	CAL Status	Uncal	DUT Mode	
Total Point	11	LO Freq	3 600 000 000Hz	ENR Status	Table		
Result						Down Convertor	
Reference	4.00 dB 1.000 dB/div	Noise I	igure			Convert	
8.00						Setup	
7.00							
5.00						External L0	
4.00						Satur	
2.00						Setup	
1.00						t.	
0.00						Loss Comp	
Reference	15.00 dB 5.000 dB/div	Ga	in				
35.00						END	
30.00						ENR	
20.00							
15.00							
500							
0.00							
-5.00							
IF Frequency Min	100 000 0	00Hz	IF Frequency Max	3 600 00	00 000Hz		
MKR	Fre	quency	Trace1 Level	Trace2 Leve	1		
						l.	
						Cal Setup	
Refint Pre	-Amp Op						

Fig. 4-8. DUT Mode Setting Display

↑ MS2830A Noise Fig	gure					2/20/2014 13:39:40	
BW	4 000 000Hz	ATT	0dB	Loss Status	Before:Off	🕌 Noise Figure 🛛 🕷	
Start Frequency	100 000 000Hz	DUT	Down Convertor		After:Off	Convert Setup	
Stop Frequency	3 600 000 000Hz	Tcold	296.50K	CAL Status	Uncal		
Total Point	11	LO Freq	3 600 000 000Hz	ENR Status	Table		LO Mode
Result							Setting Key
Reference	4.00 dB 1.000 dB/div	Noise F	igure			LO Mode	Octaing Rey
8.00						Fixed	
7.00							
5.00						Local Freq	
4.00						2 000011	
2.00						3.600GHZ	Set Local Freg when LO
1.00						IC Care	Made is Fixed
0.00						IF Freq	IVIODE IS FIXED
Reference	15.00 dB 5.000 dB/div	Gai	in			30.00MHz	Set IF Frequency when LC
35.00						LO Power	Mode is variable
30.00						-20.00dBm	
20.00						L	
15.00							
5.00							
-500							
IF Frequency Min	100 000 00	00Hz	IF Frequency Max	3 600 000	000Hz		Side Band Mode
MKR	Fre	quency	Trace1 Level	Trace2 Level			Setting Key
						Side Band Mode	
						I SP	
Refint Pre-	-Amp On					LOB	
110-	The one					0	

Fig. 4-9. LO Mode, Side Band Mode Setting Display



Fig. 4-10. LO Control Setting Display

2) Input the ENR value

The files can be read as shown in Figs. 3-3 to 3-6, but it is also possible to perform direct the ENR value as shown in Figs. 4-11 to 4-14.

Press the [Edit] key to change the ENR value at each frequency and the frequency.

When using a different noise source at measurement from the noise source used at calibration, select CAL Table after pressing the [Use Table for CAL] key as shown in Fig. 4-12, and input the ENR value of the noise source used at calibration to the CAL Table.

[Procedure]

Set the ENR value and save the ENR table.

- 1. Press [Common Setting].
- 2. Press [ENR].
- 3. Press [Meas Table].
- 4. Press [Edit].
- 5. Press [Freqency] and set the frequency to10MHz.
- 6. Set the ENR value to 15.2dB.
- 7. Set each the frequency and the ENR value that it is wrote on the noise source.
- 8. Press [Save Meas Table] to save the ENR value.



Fig. 4-11. ENR Setting Display



Fig. 4-12. Meas Table and CAL Table Setting Display



Fig. 4-13. ENR Value Edit Function Setting Display

BW 4000000Hz ATT 00B Loss Status Before.0T Start Frequency 30000000Hz T-cold 20950K CAL Status Before.0T Total Point 11 LO Freq 100000000Hz T-cold 20950K CAL Status T-able Result Stytem Up Reference Notes Figure Trace Status T-able Point 42 Meas Table Point 1 LO Freq 10000000 00Hz T-cold Point 42 Meas Table Point 1 LO Freq 10000000 152 1 0000000 152 1 0000000 152 1 0000000 152 1 0000000 152 1 0000000 152 1 1 1 1 0000000 152 1 1 1 1 0000000 152 1 1 2 00000 152 1 1 2 00000 152 1 1 2 00000 152 1 1 2 00000 000 152 1 1 2 0000 000 00 1 1 2 0 1 1 1 1 1 0 000 000 000 152 1 1 2 0000 000 00 1 1 2 0 1 1 1 1 1 1 0 000 0000 00 1 1 2 0 1 1 1 1 1 1 0 000 0000 00 1 1 1 1 1 1 1 0 000 0000 0	∧ MS2830A Noise	Figure				_0	2/20/2014 13:48:34	
Start Frequency 3 600 000 Hz DUT Down Convertor Stop Frequency 3 600 000 000Hz T cold 296.50K CAI Status 0 K Referent Moine Figure Meas Table Foditor Meas Table Frequency(kz) Meas Table Valad(B) 1 10000000 152 1 10000000 152 1 100000000 152 1 100000000 0 152 1 1000000000 0000000000000000000000000	вw	4 000 000Hz	ATT	0dB	Loss Status	Before:Off	🐕 Noise Figure 🛛 👘	
Stop Frequency 3 600 000 Hz T cold 296 50K CAL Status Table Total Point 1 LO Freq 10 000 000 000 Hz Table Reference More Figure. Meas Table Point Meas Table Frequency(k) Meas Table Frequency(k) Meas Table Frequency(k) Meas Table Frequency(k) Meas Table Value(B) + 10 000 000 152 + 10 000 000 000 + 10 000 000 152 + 10 000 000 000 152 + 10 000 000 000 152 + 10 000 000 000 152 + 10 000 000 000 152 + 10 000 000 000 152 + 10 000 000 000 152 + 10 000 000 000 152 + 10 000 000 000 + 10 000 000 000 + 10 000 00	Start Frequency	40 000 000Hz	DUT	Down Convertor		After:Off	Meas Table Edit	
Table Point 1 LO Freq 10 000 000 000 Hz Table Table Table Result Ware Up Mode Figure I 1 Frequency, ENR Edit Key Mode Figure Mode Figure I I Frequency I Mode Table Total Point I I Frequency I Image Table Fostion Mess Table Frequency(Hz) Mess Table Value(Hz) Image Table Image Table Image Table Fostion Mess Table Frequency(Hz) Mess Table Value(Hz) Image Table Image Table Image Table Fostion Mess Table Frequency(Hz) Mess Table Value(Hz) Image Table Image Table Fostion Mess Table Frequency(Hz) Mess Table Value(Hz) Image Table Image Table Fostion Mess Table Frequency(Hz) Mess Table Value(Hz) Image Table Image Table Fostion Mess Table Frequency(Hz) Mess Table Value(Hz) Image Table Image Table Image Table Image Table Image Table	Stop Frequency	3 600 000 000Hz	T cold	296 50K	CAL Status	OK	Desition	
Referent Varm Up Referent Varm Up Referent Varm Up Meas Table Position Meas Table Frequency(Ft2) Meas Table Value(B) A 100000000 152 10000000 152 10000000 152 1100000000 152 152 152 Referent 9 152 152 152 152 152 152 152 152	Total Point	11			CAL Status		Position	
Referent Mose Table Total Point 42 Mess Table Position Mess Table Frequency(Hz) Mess Table Value(Hz) 10000 000 100 10000000 152 152 100 10000000 152 152 100 10000000 152 152 100 10000000 152 152 100 10000000 152 152 100 10000000 152 152 110 90000000 152 152 111 900000000 152 152 111 90000000 152 152 111 90000000 152 152 111 100000000 152 152 111 11000000000 152 152 111 110000000000 152 152 111 111 112 112 112 111 112 112 112 112 111 113 110000000000 152 112 111 112 112 112 112			LOFIEY	10 000 000 000Hz	ENK Status	Table	1	- Frequency ENR Edit Key
Referend F Nodes Fraue Meas Table Total Point 42 10 Meas Table Frequency(Hz) Meas Table Value(B) 1 10 10 0000 152 10 10 152 152 10 10 152 10 152 152 10 152 152 10 152 152 11 10 152 11 10 152 11 10 152 11 10 152 11 10 152 11 10 152 11 10 152 11 10 152 11 10 152 11 10 152 11 10 152 11 10 152 11 10 152 11 10 152 11 10 152 11 10 152 12 10 152 13	Result X warm Up	p						riequency, LINK Luit Key
Moas Table Total Point 42 Mess Table Mess Table 10 0000 2 100 000 152 2 100 000 152 3 100 000 152 4 2000 152 5 3000 0000 152 8 6 000 0000 152 8 6 000 0000 152 11 9 000 0000 152 12 10 000000 152 13 11 00000000 152 14 12 0000 152 15 13 00000000 152 16 14 12 0000 000 152 15 13 00000000 152 16 14 12 0000 000 152 17 15 13 00000000 152 18 14 40000 0000 152 19 16 00000000 152 19 16 0000000000 152 19 16 000000000000000000000000000000000000	Reference Main Not	ise Figure				<u> </u>	Frequency	
Image: Table Position Mease Table Projection Mease Table Value(2B) Image: Table Position Mease Table Value(2B) Image: Table Value(2B) Image		oas Tablo		Tatal Paint		42	40.00141	
Meas lable Point Meas lable Value(dE) 1 1000000 152 2 1000000 152 4 2000000 152 4 2000000 152 5 30000000 152 6 4000000 152 8 6000000 152 8 6000000000 152 8 6000000000 152 10 8000 152 11 9000000 152 12 10000000000 152 13 1100000000000000000000000000000000000	8.00 - IVIC		(The Full		- [up]	TU.UUMHz	
400 400 400 100 100 100 100 100 100 100	6.00	Meas Table Position	Mea	s Table Frequency[Hz]	Meas lable Va		8	
400 - - 1000 000 152 100 - - - 152 152 100 - - - - 152 100 - - - - - 100 - - - - - 100 - - - - - 100 - - - - - 11 - 000 000 152 - 11 - 000 000 152 - 11 - 000 000 152 - 110 000 000 152 - - 111 - 000 000 152 - 112 1000 000 152 - - 113 16 000 000 152 - - 1100 - - - - - - - 1100 - - -	5.00 -			100.000.000		15.2	ENR	
300 4 2000 000 000 152 5 3 000 000 000 152 6 4 000 000 000 152 7 5 000 000 000 152 8 6 000 000 000 152 8 7 000 000 152 9 7 000 000 152 11 9 000 000 152 12 10 000 000 152 13 11 000 000 000 152 14 2 000 000 152 15 13 000 000 152 16 14 000 000 152 17 15 000 000 152 18 10 000 000 152 19 10 000 152 19 10 000 152 19 10 000 152 19 10 000 152 19 10 000 152 19 10 000 152 19 10 000 152 19 10 000 152 19 10 000 152 10 10 000 152 <th>4.00</th> <th>3</th> <th></th> <th>1 000 000 000</th> <th></th> <th>15.2</th> <th>45 000 10</th> <th></th>	4.00	3		1 000 000 000		15.2	45 000 10	
100 5 3 000 000 000 152 7 5 000 000 000 152 7 5 000 000 000 152 8 6 000 0000 152 10 8 00 0000 152 11 9 000 0000 152 12 10 000 0000 152 13 11 000 000 000 152 14 12 000 0000 000 152 15 13 000 000 152 16 14 40 000 000 000 152 17 15 000 0000 152 18 16 00000 152 18 16 00000 152 18 16 0000000 152 18 16 00000000 152 19 18 16 00000000 190 18 16 00000000 180 180 00000000 152 18 16 000000000 152 18 16 0000000000 152 18 16 0000000000 152 19 18 000000000000000000000000000000000000	3.00 -			2 000 000 000		15.2	15.200dB	
000 6 4 000 000 000 152 7 7 5 000 000 152 8 6 000 000 000 152 10 8 000 000 000 152 11 9 07 000 000 152 12 10 000 000 000 152 13 11 000 000 000 152 15 13 000 000 000 152 16 14 000 000 000 152 17 15 000 000 000 152 18 14 000 000 000 152 19 18 14 000 000 10 18 000 000 000 152 11 15 000 000 000 152 11 15 000 000 000 152 11 15 000 000 000 152 11 15 000 000 000 152 12 13 000 000 000 152 13 15 000 000 000 152 14 12 000 000 000 152 13 15 000 000 000 152 14 12 000 000 000 152 15 14 000 000 000 152 15 15 000 000	2.00			3 000 000 000		15.2		
Reference 9 7 000 000 0000 152 9 7 000 000 0000 152 10 8 000 0000 152 11 9 000 0000 152 12 10 000 0000 152 13 11 000 0000 152 16 14 000 0000 152 17 15 000 0000 152 18 10 000 0000 152 19 17 15 000 0000 192 13 10 000 0000 100 10000 152 11 9 000 0000 152 100 15 13 000 0000 100 152 1 11 10 000 0000 152 11 10 000 0000 152 11 10 000 0000 152 11 11 10 000 0000 11 11 10 000 0000 12 11 11 14 12 000 000 0000 152 15 13 000 000 0000 152 16 14 00 000 0000000 152 17	0.00	6		4 000 000 000		15.2		
Reference 9 7000 0000 0000 132 10 8000 0000 0000 152 11 9000 0000 000 152 12 10000 0000 000 152 13 11000 0000 000 152 150 14 12 000 0000 000 152 16 14 000 0000 152 18 16 000 0000 152 19 18 16 000 000 152 19 18 16 000 000 152 19 18 16 000 000 152 10 18 16 000 000 152 11 18 1000 000 152 10 13 16 000 000 152 11 13 16 000 000 152 11 13 16 000 000 152 12 13 16 000 000 152 13 16 000 000 152 14 17 race1 Level Trace2 Level MKR Frequency Min 40 0000 000Hz <t< th=""><th></th><th>/</th><th></th><th>5 000 000 000</th><th></th><th>15.2</th><th></th><th></th></t<>		/		5 000 000 000		15.2		
Referend 10 500 12 11 8000 000 152 12 1000 000 152 13 11 000 000 100 152 152 114 120000 152 150 15 13000 152 16 14000 152 118 1600000 152 118 1600000 152 118 16000000 152 118 16000000 152 118 16000000 152 118 160000000 152 118 160000000 152 12 17 1500000000 139 160000000 152 118 160000000 152 119 1600000000 152 12 17 15000000000 1300 160000000 152 1300 16000000000000000000000000000000000000		8		7 000 000 000		15.2		
3500 11 000000000000000000000000000000000000	Referenc	9		2 000 000 000		15.2		
12 10 000 000 000 152 13 11 000 000 000 152 14 12 000 000 000 152 15 13 000 000 000 152 16 14 000 000 000 152 17 15 000 000 152 18 18 000 0000 152 18 18 000 0000 152 18 18 000 0000 152 18 18 000 0000 152 18 18 000 0000 152 18 18 000 0000 152 18 18 000 0000 152 19 10 000 0000 152 10 18 10 000 0000 13 11 F Frequency Max 3 600 000 000Hz 11 Trace1 Level Trace2 Level Sort Table Sort Table		10		9,000,000,000		15.2		
13 11 000 0000 000 152 14 12 000 0000 000 152 15 13 000 0000 000 152 16 14 000 0000 000 152 17 15 000 0000 000 152 18 16 0000 000 152 18 16 0000 000 152 18 16 0000 000 152 18 16 0000 000 152 18 16 0000 000 152 18 16 0000 000 152 18 16 0000 000 152 18 16 0000 000 152 18 16 0000 000 152 18 16 0000 000 152 18 10 000 000 152 19 18 00000 152 19 18 000000 152 19 18 00000000 152 10 18 000000000 152 10 10 00000000000000000000000000000000000	35.00 -	12		10 000 000 000		15.2		
2000 14 12 000 000 000 152 15 13 000 0000 000 152 16 14 000 000 000 152 17 15 000 000 152 13 16 000 000 152 13 16 000 000 152 18 18 000 000 152 19 13 16 000 000 19 12 Insert Point Below IF Frequency Min 40 000 000Hz IF Frequency Max 3 600 000 000Hz MKR Frequency Trace1 Level Trace2 Level Sort Table Ref.Int Pre-Amp On Image: Contract C	30.00 -			11 000 000 000		15.2		
1500 15 13 000 000 000 152 160 14 000 0000 152 17 15 000 000 152 18 16 00000 152 18 16 0000000 152 18 16 0000000 152 IF Frequency Min 40 000 000Hz IF Frequency Max 3 600 000 000Hz MKR Frequency Trace1 Level Trace2 Level Sort Table Sort Table	25.00 -	14		12 000 000 000		15.2		
16 14 000 000 000 152 17 15 000 0000 152 18 16 000 000 000 152 19 18 16 000 000 19 18 16 000 000 19 18 16 000 000 19 18 16 000 000 19 18 16 000 000 19 18 16 000 000 19 19 19 IF Frequency Min 40 000 000Hz IF Frequency Max 3 600 000 000Hz MKR Frequency Trace1 Level Trace2 Level Mira Sort Table Sort Table	20.00 -	15		13 000 000 000		15.2		
Insert Prior Insert Point Below Insert Point Below Insert Point Below	1000 -	16		14 000 000 000		15.2		
18 18 18 182 IF Frequency Min 40 000 000Hz IF Frequency Max 3 600 000 000Hz MKR Frequency Trace1 Level Trace2 Level MKR Frequency Trace1 Level Sort Table	500	1/				15.2	Insert Point Below	
-600 L IF Frequency Min 40 000 000Hz IF Frequency Max 3 600 000 000Hz MKR Frequency Trace1 Level Trace2 Level Sort Table Ref.Int Pre-Amp On	0.00	10		18 000 000 000		J.2 🗸		
IF Frequency Min 40 000 000Hz IF Frequency Max 3 600 000 000Hz MKR Frequency Trace1 Level Trace2 Level Sort Table	-5.00							
IF Frequency Min 40 000 000Hz IF Frequency Max 3 600 000 000Hz MKR Frequency Trace1 Level Trace2 Level MKR Frequency Sort Table						· · · · · · · · · · · · · · · · · · ·		
MKR Frequency Trace1 Level Trace2 Level Sort Table	IF Frequency Mi	in 40 000 0	00Hz	IF Frequency Max	3 600 00	0 000Hz	Delete Point	
Ref.Int Pre-Amp On	MKR	Fre	quency	Trace1 Level	Trace2 Leve			
Ref.Int Pre-Amp On								
Ref.Int Pre-Amp On							Sort Table	
Ref.int Pre-Amp On								
	Ref.Int P	re-Amp On						

Fig. 4-14. ENR Value Editing Display



Fig. 4-15. Save the ENR Value Setting Display

Next, set the measurement frequency, number of measurement points, measurement bandwidth, analysis time length, and Storage On/Off setting. These operations are the same as shown in Figs. 3-7 and 3-8. The measurement accuracy is improved by lengthening the analysis time and performing averaging by setting Storage On/Off but there is a trade-off in longer measurement time.



Fig. 4-16. Measurement Frequency Setting Display



Fig. 4-17. Measurement Conditions Setting Display

3) Executes calibration. (Obtain the NF of the measurement system.) Executes calibration by pressing the [Calibration Now] key shown in Fig. 4-18. Additionally, calibration can be stopped by pressing the [Cancel] key shown in Fig. 4-19. (Calibration is finished when the Calibration Progress bar reaches 100%.)

[Procedure] Executes calibration.

- 1. Press [Common Setting].
- 2. Press [Cal Setup].
- 3. Press [Calibration Now]



Fig. 4-18. Calibration Display



Fig. 4-19. Calibration Progress Display

4) Perform measurement with the DUT connected.

Using the calibrated system, connect the DUT between the noise source and measurement system (spectrum analyzer). The NF calculated at this time using the Y factor method is the total NF (of the DUT and measurement system).

The NF measurement function calculates the NF of the DUT (NF_1) using Eq. 7 from the NF measured when the DUT is connected (NF_t) and the NF of the measurement system measured at calibration (NF_2), and shows calculating result in a table or graph.

DUT Setup



Fig. 4-20. Measurement Setup at DUT Connection

Operate the Measure key to switch the display layout.

[Procedure]

Switch the display layout to the table from the graph.

- 1. Press [Measure].
- 2. Press [Layout].



Fig. 4-21. Measurement Results Display (Graph)

A 1/000000							9/94/9014 11:49:50
/I MS2830A	Noise Figure						2/24/2014 11:42:30
BW		4 000 000Hz	ATT	0d	B Loss Status	Before:Off	Frequency
			DUT	Down Converte	or	After:Off	in equancy
			T cold	296.50	K CAL Status	ок	Frequency Mode
Total Point		11	LO Frec	8 000 000 000	Z ENR Status	Table	Liet
Result							List
		_					ų.
	IF F	requency	/	Noise Figure	Gain		Fixed Setting
	1 010	000 000H	Z	-0.33256dB	0.24238d	в	L. L.
	1 110	000 000H	7	-0 20636dB	0 19651d	R	List Setting
	4 240			0.2424040	0.126204		List sotting
	1 210		2	-0.242180B	0.176790		
	1 310	000 000H	Z	-0.19268dB	0.14620d	B	
	1 410	000 000H	z	-0.11854dB	0.12229d	в	Sweep Setting
	1 510		-	0.07310dB	0 102734		1
	1 310		2	-0.073190B	0.102750		
	1 610	000 000H	Z	-0.00478dB	0.0223/d	в	
	1 710	000 000H	z	0.00146dB	0.01623d	B	
	1 810	000 0000	7	0.05786dB	-0 026904	e 🗌	
	1 0 1 0		2	0.00750.10	-0.020300		
	1 910	000 000H	Z	-0.00758dB	-0.02297d	B	
	2 010	000 000H	Z	0.16896dB	-0.09413dl	B	
IF Freque	ency Min	1 010 000 00	0Hz	IF Frequency Max	2 010 000	000Hz	
Ref.Ext	Pre-Amp	o On					- C

Fig. 4-22. Measurement Results Display (Table)

Sometimes, it may be necessary to insert filters before and after the DUT when unwanted responses such as image responses and LO leak occur at mixer measurement. Additionally, it may be necessary to insert an attenuator to match impedance or an amplifier to increase measurement accuracy.

In these cases when the measurement results include a filter or attenuator, the Loss Comp function can be used to measure the losses of parts other than the DUT to extract the value for the DUT from the measurement results for the overall system.



Fig. 4-23. Measurement Setup when Attenuator and Amp, etc., Connected Before and After DUT

[Procedure]

Set the Loss Comp. For example, Before DUT Loss is 3.1dB and After DUT Loss is 7.8dB.

- 1. Press [Common Setting].
- 2. Press [Loss Comp].
- 3. Press [Before DUT].
- 4. Select [Fixed].
- 5. Press [Before DUT Fixed] and set 3.1dB with the Before DUT Loss.
- 6. Press [After DUT].
- 7. Select [Fixed].
- 8. Press [After DUT Fixed] and set 7.8dB with the After DUT Loss.



Fig. 4-24. Loss Comp Setting Display



Fig. 4-25. Before DUT, After DUT Setting Display

5. Other Measurement Precautions

External Factors

Since NF measurements involve measurement of extremely small noise powers, it is necessary to consider the status of the DUT.

For example, when measuring an environment with wireless communications such as mobile telephones, the impact of these wireless signals cannot be ignored and sometimes it may be difficult to obtain accurate measurement results.

If the DUT is affected by external factors and the measurement results are believed to be inaccurate, measurement errors may be prevented by protecting the DUT from external factors by using the shield case.

Gain Measurement Range

At NF measurement, it may sometimes be necessary to pay heed to the measurement range at gain measurement. Gain measurement means determining the slope of the line shown in Figure 2-1 due to parameters having an effect at calibration and when the DUT is connected.

As an example, consider the case when using a noise source with an *ENR* of 24 dB. When this noise source is off, wideband noise of about -174 dBm/Hz is output; when it is on, wideband noise of about -150 dBm/Hz is output. These noise components are band controlled by the stage before the mixer input due to the spectrum analyzer internal blocks and are input to the 1st Mixer of the spectrum analyzer. As a result, when the noise source is connected directly to the spectrum analyzer and the noise source is on, the mixer input level is -150 dBm/Hz + 10*Log (6 GHz) = -52 dBm/6 GHz.

On the other hand, the spectrum analyzer linearity error performance must be considered. Since linearity error indicates the error in the spectrum analyzer at relative value measurement, it must be assured at some input level. As a result, if a higher input level is input to the spectrum analyzer, the gain cannot be measured accurately because linearity cannot be assured due to distortion at the internal semiconductor parts.

At NF measurement, always choose a noise source with an ENR matching the gain and bandwidth of the DUT to be measured and set the attenuator at measurement.

Noise source selection

Note the following points when selecting the noise source.

Many noise sources impress bias on an avalanche diode to generate wideband noise when the avalanche collapses. However, due to this operation principle, sometimes there may be DC voltage at the output of the noise source. (Depending on the noise source, there may be an internal filter to block this DC voltage so there is no DC voltage at the output terminal.)

When using this type of noise source, perform measurements with the DC filter block inserted at the input of the spectrum analyzer.

Supports noise sources from Noisecom NC346 series. NC346 series models and summary specifications are listed below. See the NC346 series catalog and datasheet for detailed specifications.

Tables-1. NC346 series summary specifications										
Model	RF Connector	Frequency [GHz]	Output ENR [dB]	DC Offset	DC Block					
NC346A	SMA (M)	0.01 to 18.0	5 to 7	No	Not required					
NC346A Precision	APC3.5 (M)	0.01 to 18.0	5 to 7	No	Not required					
NC346A Option 1	N (M)	0.01 to 18.0	5 to 7	No	Not required					
NC346A Option 2	APC7	0.01 to 18.0	5 to 7	No	Not required					
NC346A Option 4	N (F)	0.01 to 18.0	5 to 7	No	Not required					
NC346B	SMA (M)	0.01 to 18.0	14 to 16	No	Not required					
NC346B Precision	APC3.5 (M)	0.01 to 18.0	14 to 16	No	Not required					
NC346B Option 1	N (M)	0.01 to 18.0	14 to 16	No	Not required					
NC346B Option 2	APC7	0.01 to 18.0	14 to 16	No	Not required					
NC346B Option 4	N (F)	0.01 to 18.0	14 to 16	No	Not required					
NC346D	SMA (M)	0.01 to 18.0	19 to 25*1	No	Not required					
NC346D Precision	APC3.5 (M)	0.01 to 18.0	19 to 25 ^{*1}	No	Not required					
NC346D Option 1	N (M)	0.01 to 18.0	19 to 25*1	No	Not required					
NC346D Option 2	APC7	0.01 to 18.0	19 to 25*1	No	Not required					
NC346D Option 3	N (F)	0.01 to 18.0	19 to 25*1	No	Not required					
NC346C	APC3.5 (M)	0.01 to 26.5	13 to 17	Yes ^{*3}	Required ^{*3}					
NC346E	APC3.5 (M)	0.01 to 26.5	19 to 25 ^{*1}	Yes ^{*3}	Required ^{*3}					
NC346Ka	K (M)*2	0.10 to 40.0	10 to 17	Yes*3	Required ^{*3}					

TableE 1 NC246 series summary enseifications

*1: Flatness better than ±2 dB *2: Compatible with SMA and APC3.5

*3: When using noise sources output by DC, always use in combination with a DC block.

Table5-2. Specifications outlines of recommended DC Blocks and Adapters

		Ordaring	PE Connector	Fragueney Panga
	Model	Name	RF Connector	Frequency Range
	J0805	DC Block, N type (MODEL 7003)	N (M)-N (F)	10 kHz to 18 GHz
DC Block	J1555A	DC Block, SMA type (MODEL 7006-1)	SMA (M)-SMA (F)	9 kHz to 20 GHz
DC BIOCK	J1554A	DC Block, SMA type (MODEL 7006)	SMA (M)-SMA (F)	9 kHz to 26.5 GHz
	K261	DC Block	K (M)-K (F)	10 kHz to 40 GHz
	J0004	Coaxial Adapter	N (M)-SMA (F)	DC to 12.4 GHz
Adapter	J1398A	N-SMA Adapter	N (M)-SMA (F)	DC to 26.5 GHz

Table5-3. Recommended DC blocks / Adaptor combinations for MS269xA/MS2840A/MS2830A series signal analyzer.

	Model	Frequency Range	RF connector	Recommended DC Block	Recommended Adapter
				Order Name	Order Name
MS269xA	MS2690A	50 Hz to 6 GHz	N (F)	J1555A	J0004
Series	MS2691A	50 Hz to 13.5 GHz	N (F)	J1555A	J1398A
	MS2692A	50 Hz to 26.5 GHz	N (F)	J1554A	J1398A
MS2840A	MS2840A-046	9 kHz to 44.5 GHz	K (F)	K261	Not Required
MS2830A	MS2830A-040	9 kHz to 3.6 GHz	N (F)	Not Required	Not Required
Series	MS2830A-041	9 kHz to 6 GHz	N (F)	Not Required	Not Required
	MS2830A-043	9 kHz to 13.5 GHz	N (F)	Not Required	Not Required
	MS2830A-044	9 kHz to 26.5 GHz	N (F)	J1554A	J1398A
	MS2830A-045	9 kHz to 43 GHz	K (F)	K261	Not Required

6. Uncertainty of NF Measurement Methods

As explained in the previous section, the Y factor method supports DUT *NF* measurements. This section explains the uncertainty of NF measurements.

The following figures show the uncertainty at calibration and when the DUT is connected.



(1) ENR uncertainty causes an error when calculating the Noise Factor, *F*. *Refer to Ref. (13).

(2) This uncertainty is caused by the spectrum analyzer level resolution. It is uncertainty due to the internal calculation of the NF of the spectrum analyzer obtained from calibration.

(3) This uncertainty is caused by the spectrum analyzer linearity error.

*When determining the *NF* of the DUT using the Y factor method, the DUT gain must be measured. It can be found from the gradient of data as shown in Figure 2-1 calculated from the measurement results when the DUT is connected at calibration. When measuring the relative values of the two levels at the spectrum analyzer (at calibration and with DUT connected), the uncertainty is standardized as the linearity error.

(4) This is mismatch error between the noise source and spectrum analyzer at calibration.

(5) This is mismatch error between the noise source and DUT when the DUT is connected.

(6) This is mismatch error between the DUT and spectrum analyzer when the DUT is connected.

The values of these uncertainties vary, depending on the DUT and the ENR of the noise source. As a result, an Uncertainty Calculator tool is provided to calculate the uncertainty by inputting parameters (1) to (6).

The uncertainty of the NF found by the NF Measurement Function can be calculated by inputting the parameters for (1) to (6) and the measurement results into the following Uncertainty Calculator.

			Uncertain	ity	y Calculator			
							01,N	ovember,2012
					Capyright(C) Annitsu Carpor		u Corporation	
This screadsheet calcu	ulates the tota	l unce	rtainty of noise figure n	nea	surement.			
Please input paramete	rs af vaur devi	ices an	d environment into the	. ar	ange cells.			
Far mare information.	please see the	e ‴Tut	orial" spreadsheet					
	Joput Paramet	ter						
Calculation Result								
			Maan		Paura atau			
		Linit	Linear		r aralleter			
Termoewatuwe	295.5	K	Linear	\square				
kTB	-173 88095	dBm.						
DUT NE: E1=	3	and a	1,995262315		F12/F1=	1.09149013		
Y fector	4	-	2.511886432					
ENR	15	an	31.8227788					
DANL	-161.0358							
Instrument NF: F2=	12.8453632	æ	19.25468049		F2/F1G1=	0.096502		
DUT GAIN : G1=	20	and a	100		(F2-1)/F1G1=	0.09149013		
Combined NF: F12=	3.38019812		2.17760912		(F12/F1)-(F2/F1B1)=	0,99498813		
			Mia	met	sh Errar			
Metch	VSWR	Unit	Reflection coefficient			Negative	Positive	Max
Naise Saurae=	1.1	-	0.047619048		Uncertain NS-DUT IN=	0.0831192	0.08233132	0.0831192
DUT hput=	1.5	-	0.2		Uncertain NS-NFA=	0.11898665	0.11737887	0.11898665
DUT Output=	1.5	-	0.2		Uncertain DUT OUT-NFA=	0.51108209	0.48267359	0.51108209
Instrument=	1.8		0.285714288					
Instrument=	1.8	-	0.285714286 System	ᇞ	Incertainty			
Instrument≍ Uncertainties	1.8	- Unit	0.285714285 System		Incertainty			
Instrument= Uncertainties Instrument NF=	0.02	Unit	0.285714285 Svoter *1		Incertainty Uncertain NF12=	0.19842503		
Instrument= Uncertainties Instrument NF= Gain Uncertainty=	0.02 0.07	Unit dB	0.285714288 Svater ¥1 ¥3		Incertainty Uncertain NF12= Uncertain NF2=	0.19842503		
Instrument= Uncertainties Instrument NF= Gain Uncertainty= Naise Source ENR=	1.8 0.02 0.07 0.18	- Unit 68 68	0.285714288 System *1 *3 (Amplifiers Only)*2		Insertainty Unsertain NF12= Unsertain NF2= Unsertain G1=	0.19842503 0.21532109 0.55798117		
Instrument= Uncertainties Instrument NF= Gain Uncertainty= Naise Saurce ENR= Naise Saurce ENR=	1.8 0.02 0.07 0.18 0.18	- Unit 68 68 68 68	0.285714285 System *1 *3 (Amplifiers Dnly)*2 (Receivers Dnly)*2		Insertainty Unsertain NF12= Unsertain NF2= Unsertain G1= Unsertain ENR=	0.19842503 0.21532109 0.55798117 0.18		
Instrument= Uncertainties Instrument NF= Gain Uncertainty= Naise Source ENR= Naise Source ENR=	1.8 0.02 0.07 0.18 0.18	- Unit 48 48 48 48	0.285714285 System *1 *3 (Amplifiers Only)*2 (Receivers Only)*2		Insertainty Uncertain NF12= Uncertain NF2= Uncertain G1= Uncertain ENR= Total Uncertainty =	0.19642503 0.21532109 0.55796117 0.18 0.28348851		
Instrument= Uncertainties Instrument NF= Gain Uncertainty= Naise Source ENR= Naise Source ENR= *1::Instrument NF Un-	1.8 0.02 0.07 0.18 0.18	- 48 48 48 48	0.285714285 System *1 *3 (Amplifiers Only)*2 (Receivers Only)*2		Insertainty Uncertain NF12= Uncertain NF2= Uncertain G1= Uncertain ENR= Total Uncertainty =	0.19642503 0.21532109 0.55796117 0.18 0.28348851	68	
Instrument= Uncertainties Instrument NF= Gain Uncertainty= Naise Source ENR= Naise Source ENR= *1:Instrument NF Unc Analysis Time : Auto. <	1.8 0.02 0.07 0.18 0.18 sertain tv (+/-0.034dB	- Unit 68 68 68	0.285714285 System *1 *3 (Amplifiers Only)*2 (Receivers Only)*2		Insertainty Uncertain NF12= Uncertain NF2= Uncertain G1= Uncertain ENR= Total Uncertainty =	0.19842503 0.21532109 0.55798117 0.18 0.28348851		
Instrument= Uncertainties Instrument NF= Gain Uncertainty= Noise Source ENR= Noise Source ENR= *1 : Instrument NF Unc Andvois Time : Auto < *2 : Noise Source (AEN	1.8 0.02 0.07 0.18 0.18 certaintv (+/-0.034dB IR Uncertaintv	- 48 48 48 48	0.285714285 Skote *1 *3 (Amplifiers Only)*2 (Receivers Only)*2		Incertainty Uncertain NF12= Uncertain NF2= Uncertain G1= Uncertain ENR= Total Uncertainty =	0.19642503 0.21532109 0.55798117 0.18 0.28348851	B	
Instrument= Uncertainties Instrument NF= Gain Uncertainty= Naise Source ENR= Naise Source ENR= *1:Instrument NF Uncertainty is +/18 Uncertainty is +/18	1.8 0.02 0.07 0.18 0.18 certaintv (+/-0.034dB IR Uncertaintv dB (NC345 ≫	- dB dB dB dB	0.285714285 System *1 *3 (Amplifiers Only)*2 (Receivers Only)*2		Incertainty Uncertain NF12= Uncertain NF2= Uncertain G1= Uncertain ENR= Total Uncertainty =	0.19842503 0.21532109 0.55798117 0.18 0.28348851	8	
Instrument= Uncertainties Instrument NF= Gain Uncertainty= Noise Source ENR= Noise Source ENR= *1 : Instrument NF Uncertainty Analysis Time : Auto < *2 : Noise Source //EN Uncertainty is +/18 *3 : Gain Uncertainty	1.8 0.02 0.07 0.18 0.18 certaintv (+/-0.034dB IR Uncertaintv dB (NC346 >	- dB dB dB dB	0.285714285 System *1 *3 (Amplifiers Only)*2 (Receivers Only)*2		Insertainty Uncertain NF12= Uncertain NF2= Uncertain G1= Uncertain ENR= Total Uncertainty =	0.19842503 0.21532109 0.55798117 0.18 0.28348851		
Instrument= Uncertainties Instrument NF= Gain Uncertainty= Naise Source ENR= Naise Source ENR= *1 : Instrument NF Un- Analysis Time : Auto. < *2 : Naise Source //EN Uncertainty is +/18 *3 : Gain Uncertainty	1.8 0.02 0.07 0.18 0.18 sertaintv (+/-0.034dB IR Uncertaintv dB (NC346 >> following, So.	- dB dB dB dB (erics)	0.285714285 System *1 *3 (Amplifiers Only)*2 (Receivers Only)*2 ncertainty is effected b		Incertainty Uncertain NF12= Uncertain NF2= Uncertain G1= Uncertain ENR= Total Uncertainty = Uncertainty =	0.19842503 0.21532109 0.55798117 0.18 0.28348851	ď	
Instrument= Uncertainties Instrument NF= Gain Uncertainty= Naise Source ENR= Naise Source ENR= *1 : Instrument NF Un- Analysis Time : Auto< *2 : Naise Source //NEN Uncertainty is +/18 +3 : Gain Uncertainty Gain is defined by the Gain=(N'2-N'1)/'(N2-)	1.8 0.02 0.07 0.18 0.18 sertaintv (+/-0.034dB IR Uncertaintv dB (NC346 > following, So. N1)	- dB dB dB dB (erics)	0.285714285 Skote *1 *3 (Amplifiers Only)*2 (Receivers Only)*2 ncertainty is effected b		Incertainty Uncertain NF12= Uncertain NF2= Uncertain G1= Uncertain ENR= Total Uncertainty = Uncertainty =	0.19842503 0.21532109 0.55788117 0.18 0.28348851	dB	
Instrument Uncertainties Instrument NF= Gain Uncertainty= Naise Source ENR= Naise Source ENR= *1: Instrument NF Un- Analysis Time : Auto. < *2 : Naise Source //EN Uncertainty is +/18 *3 : Gain Uncertainty Gain is defined by the Gain=(N'2=N'1)/'(N2=) *Surport score	1.8 0.02 0.07 0.18 0.18 certaintv (+/-0.034dB IR Uncertaintv (#/-0.034dB IR Uncertaintv dB (NC346 » fallowing, So. N1)	Unit dB dB dB dB	0.285714285 Skoter *1 *3 (Amplifiers Only)*2 (Receivers Only)*2 (Receivers Only)*2		Incertainty Uncertain NF12= Uncertain NF2= Uncertain G1= Uncertain ENR= Total Uncertainty = Uncertainty =	0.19842503 0.21532109 0.55798117 0.18 0.28348851	B	

Figure6-3. Example of input to Uncertainty Calculator



The Uncertainty Calculator has been put in this application note as embedded files.

7. Summary

This Application Note explains the basic principles of NF measurement and some notes on measurement. To measure NF accurately, it is important to understand the measurement principles and to use the most appropriate measurement method.

Anritsu's MS269xA-017/MS2840A-017/MS2830A-017 Noise Figure Measurement Function is the ideal platform supporting designers requiring NF measurements.

/incitsu

United States

Anritsu Company 1155 East Collins Blvd., Suite 100, Richardson, TX 75081, U.S.A. Toll Free: 1-800-267-4878 Phone: +1-972-644-1777 Fax: +1-972-671-1877

• Canada Anritsu Electronics Ltd. 700 Silver Seven Road, Suite 120, Kanata, Ontario K2V 1C3, Canada Phone: +1-613-591-2003 Fax: +1-613-591-1006

Brazil Anritsu Eletronica Ltda. Praça Amadeu Amaral, 27 - 1 Andar 01327-010 - Bela Vista - Sao Paulo - SP Brazil Phone: +55-11-3283-2511 Fax: +55-11-3288-6940

 Mexico Anritsu Company, S.A. de C.V. Av. Ejército Nacional No. 579 Piso 9, Col. Granada 11520 México, D.F., México Phone: +52-55-1101-2370 Fax: +52-55-5254-3147

 United Kingdom Anritsu EMEĂ Ltd. 200 Capability Green, Luton, Bedfordshire, LU1 3LU, U.K. Phone: +44-1582-433200 Fax: +44-1582-731303

France

Anritsu S.A. 12 avenue du Québec, Bâtiment Iris 1- Silic 612, 91140 VILLEBON SUR YVETTE, France Phone: +33-1-60-92-15-50 Fax: +33-1-64-46-10-65

Germany

Anritsu GmbH Nemetschek Haus, Konrad-Zuse-Platz 1 81829 München, Germany Phone: +49-89-442308-0 Fax: +49-89-442308-55

• Italy Anritsu S.r.I. Via Elio Vittorini 129, 00144 Roma, Italy Phone: +39-6-509-9711 Fax: +39-6-502-2425

 Sweden Anritsu AB Kistagången 20B, 164 40 KISTA, Sweden Phone: +46-8-534-707-00 Fax: +46-8-534-707-30

Finland Anritsu AB Teknobulevardi 3-5, FI-01530 VANTAA, Finland Phone: +358-20-741-8100 Fax: +358-20-741-8111

Denmark Anritsu A/S Kay Fiskers Plads 9, 2300 Copenhagen S, Denmark Phone: +45-7211-2200 Fax: +45-7211-2210

Russia Anritsu EMEA Ltd. Representation Office in Russia Tverskaya str. 16/2, bld. 1, 7th floor. Moscow, 125009, Russia Phone: +7-495-363-1694 Fax: +7-495-935-8962

 Spain Anritsu EMEA Ltd. **Representation Office in Spain** Edificio Cuzco IV, Po. de la Castellana, 141, Pta. 8 28046, Madrid, Spain Phone: +34-915-726-761 Fax: +34-915-726-621

 United Arab Emirates Anritsu EMEA Ltd. **Dubai Liaison Office**

902, Aurora Tower, P O Box: 500311- Dubai Internet City Dubai, United Arab Emirates Phone: +971-4-3758479 Fax: +971-4-4249036

Specifications are subject to change without notice.

• India

Anritsu India Private Limited Anrisu India Private Limited 2nd & 3rd Floor, #837/1, Binnamangla 1st Stage, Indiranagar, 100ft Road, Bangalore - 560038, India Phone: +91-80-4058-1300 Fax: +91-80-4058-1301

 Singapore Anritsu Pte. Ltd. 11 Chang Charn Road, #04-01, Shriro House Singapore 159640 Phone: +65-6282-2400 Fax: +65-6282-2533

• P.R. China (Shanghai) Anritsu (China) Co., Ltd. Room 2701-2705, Tower A, New Caohejing International Business Center No. 391 Gui Ping Road Shanghai, 200233, P.R. China Phone: +86-21-6237-0898 Fax: +86-21-6237-0899

• P.R. China (Hong Kong) Anritsu Company Ltd. Unit 1006-7, 10/F., Greenfield Tower, Concordia Plaza, No. 1 Science Museum Road, Tsim Sha Tsui East, Kowloon, Hong Kong, P.R. China Phone: +852-2301-4980 Fax: +852-2301-3545 • Japan

Anritsu Corporation 8-5, Tamura-cho, Atsugi-shi, Kanagawa, 243-0016 Japan Phone: +81-46-296-6509 Fax: +81-46-225-8359

 Korea Anritsu Corporation, Ltd. 5FL, 235 Pangyoyeok-ro, Bundang-gu, Seongnam-si, Gyeonggi-do, 13494 Korea Phone: +82-31-696-7750 Fax: +82-31-696-7751

 Australia Anritsu Pty. Ltd. Unit 20, 21-35 Ricketts Road, Mount Waverley, Victoria 3149, Australia Phone: +61-3-9558-8177 Fax: +61-3-9558-8255

• Taiwan Anritsu Company Inc. 7F, No. 316, Sec. 1, NeiHu Rd., Taipei 114, Taiwan Phone: +886-2-8751-1816 Fax: +886-2-8751-1817

1603

