Telecom 205: Projet fil rouge
2019-2020

LNA Characterization
Gain - IP1 – Noise Figure

This part is dedicated to characterize a Low Noise Amplifier (LNA) by its Sij parameters to determine the Gain, the compression Gain (IP1) and the Noise Figure (NF).

The Sij parameters measurements are obtained by a Vector Network Analyzer (VNA).This one must be initially calibrated as done in the training courses in the Telecom 201 learning unit.

The amplifier to characterize is the **TB-432-8A+** from Miniciruit. This one is fit to the 100 kHz – 1 GHz frequency band. The Electrical Specifications are given here:

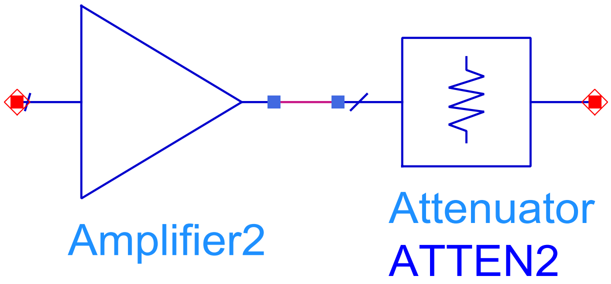
Electrical Specifications at 25°C and 36mA, unless noted

Parameter		Min.	Typ.[3]	Max.	Units
Frequency Range*		DC		1	GHz
Gain	f=0.1 GHz f=1 GHz	— 20[2]	31.5 25	— —	dB
Input Return Loss	f=DC to 1 GHz		15.5		dB
Output Return Loss	f=DC to 1 GHz		11		dB
Output Power @ 1 dB compression	f=1 GHz		+12.5		dBm
Output IP3	f=1 GHz		+25		dBm
Noise Figure	f=1 GHz		3.1		dB

1. Return Loss & Gain G

The theoritical specifications are given for 100 MHz and 1 GHz. For this project, the specifications at 900 MHz are required.

Warning : The output power can be high, so It becomes compulsory to protect the Port2 input of the VNA by adding a 10 dB attenuator as below:



The attenuator is put at the LNA output not to increase artificially the Noise Figure of the amplifier.

After calibrating the VNA in the 800MHz- 1 GHz frequency band, Give the Return Loss and the gain G of this amplifier @ 900 MHz.

2. Compression Gain (IP1)

The theoritical IP1 spécification is 12.5 dBm @ 1 GHz. It means that the amplifier gain is decreasing by 1 dB when the output power reaches this value.

Translate this value in Watt.

Measure the Amplifier Gain Vs Input Power from -30 dBm to 0dBm @ 900 MHz.

Give the IP1.

- To measure it, follow this procedure on the VNA: Click Sweep/ set sweep type/ power sweep and Sweep/ power/ cw freq 900MHz

Warning: the attenuator must be used as presented before

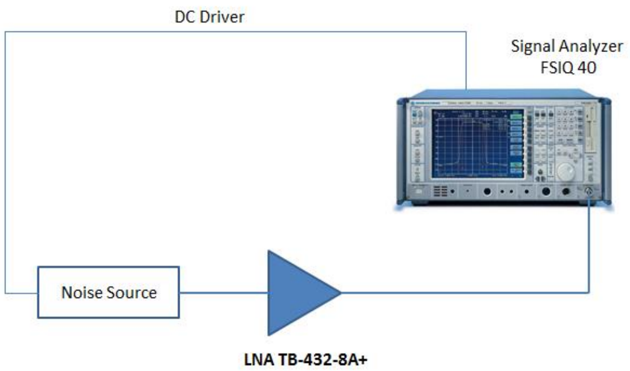
3. LNA Noise Figure Measurement

With the DC supply of the noise generator turned off, the diode inner resistance (50 Ω) is at the ambient temperature To = 290°K. The noise power produced by the diode is equal to the thermal noise k.To.B, with k= Boltzmann's constant = 1.38 10^{-21} J/°K and B the analyze frequency bandwidth of the spectrum analyzer.

When the DC supply is turn on, The noise power from the diode is equal to ($kToB+kT_RB$), kT_RB is the "avalanche" noise and can be expressed by the Excess Noise Ration (ENR). The used diode gives the following ENR:

$$ENR = \frac{kT_R B}{kT_0 B} = 15.5dB$$

How to measure :



Step 1 - DC Driver OFF : $N_{e1} = kToB$

At the output of the amplifier, there are the input noise and the ENR of the amplifier is for the T_Q temperature.

$$N_{s1} = GkToB + GkT_Q B$$

Step 2 - DC Driver ON : $N_{e2} = k(To + T_R)B$

At the amplifier output, the noise level is higher dut to a higher input noise level.

$$N_{s2} = Gk(To + T_R)B + GkT_Q B$$

Step 3 – Process the difference between N_{s1} and N_{S2} to obtain the Noise Figure NF

$$N_{s1} = N_{s2} - Y_{dB}$$

$$Y_{linéaire} = Y = \frac{N_{s2}}{N_{s1}} = \frac{To + T_R + T_Q}{To + T_Q}$$

$$T_Q = \frac{T_0 + T_R - YT_0}{T_0 + T_Q}$$

Thus

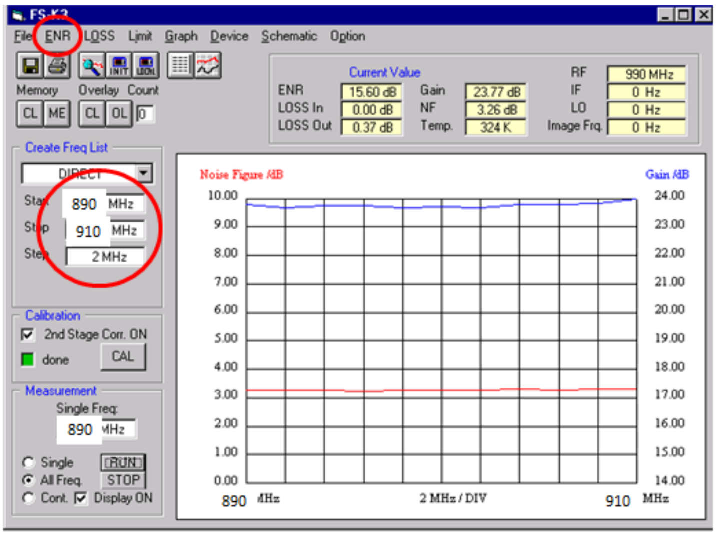
$$NF = 1 + \frac{T_Q}{T_0} = \frac{T_R}{T_0} \frac{1}{Y-1}$$

In logarithmic scale :

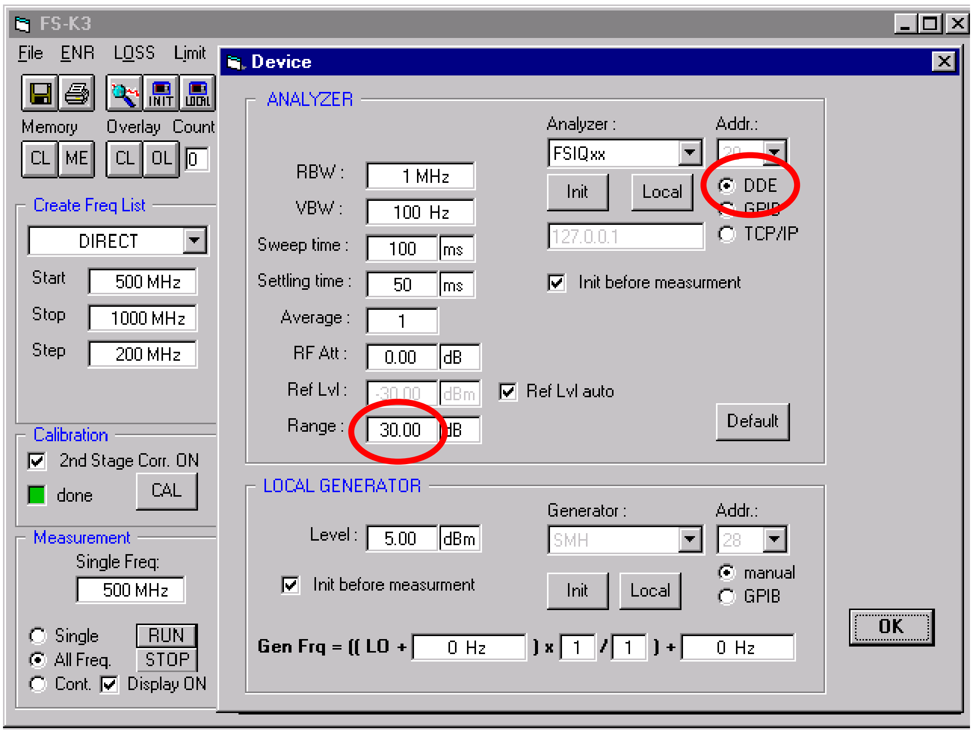
$$NF_{dB} = ENR_{dB} - 10\,\mathbf{log(}Y - 1\mathbf{)}$$

This is processed by the dedicated software included in the R&S FSIQ 40 Spectrum Analyzer as follow:

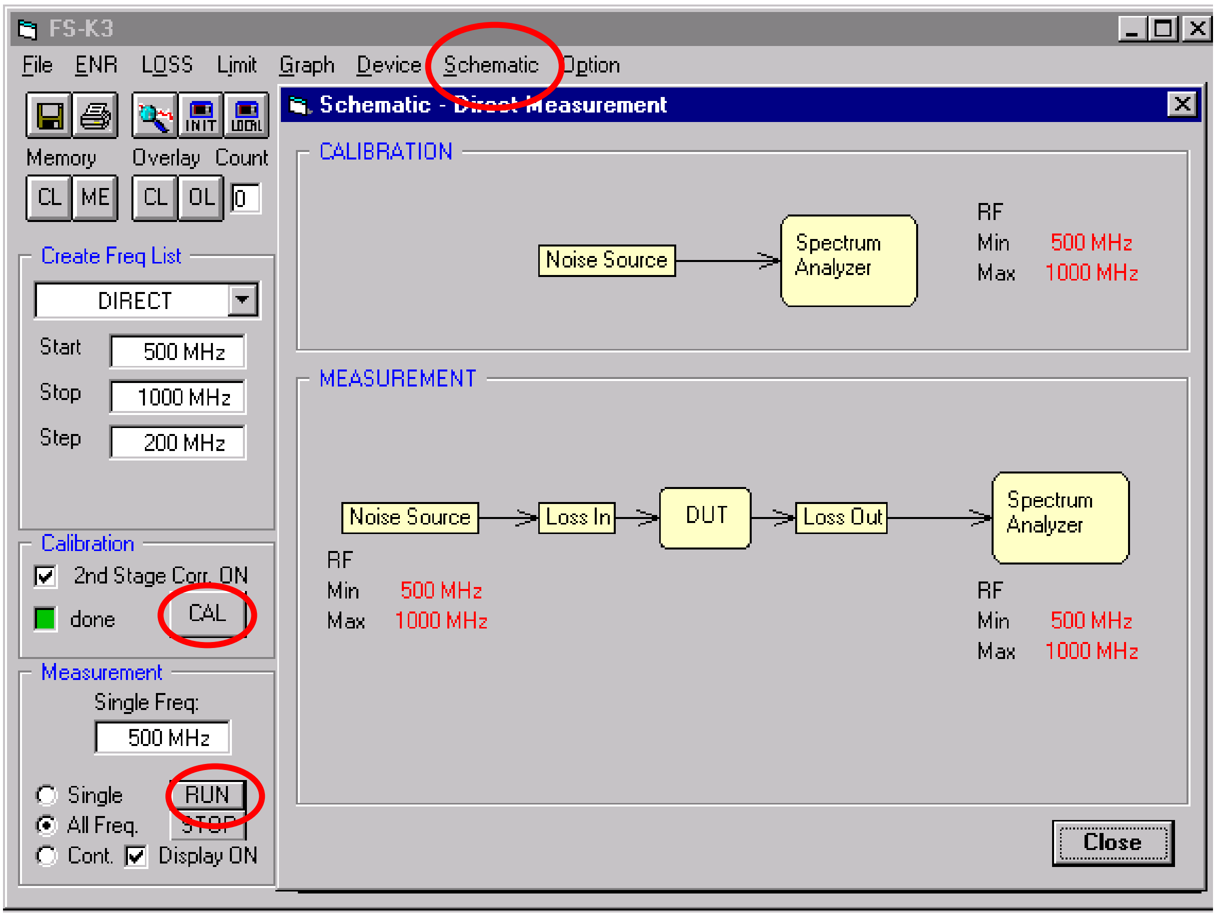
- On the Keyboard : press Alt Gr + Print Screen to access to the Windows screen
- Run the FS-K3 software
- Set the frequency bandwidth by start=890 MHz, stop=910 MHz, step=2 MHz
- Set the ENR and the temperature by press ENR



- Press **Device** and Set power range (Amplifier Gain + 10 dB) and the link type between the software and the spectrum analyzer



- Connect the Noise Source to the Analyzer and Select **Schematic** , then select **cal** to compute the Noise Figure of the Spectrum Analyzer



- Next Connect the noise source to the input port of the amplifier (or DUT) and the output port to the analyzer. By selecting the **LOSS** window, set the loss output at 0.37 dB
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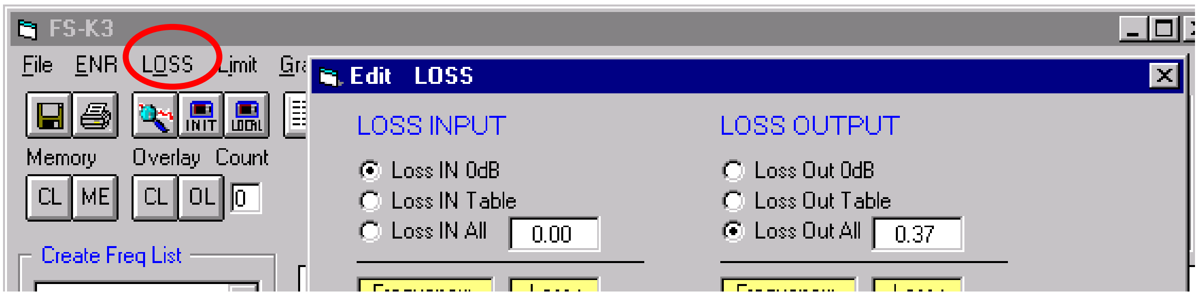

To process it, Press **Run** and when it is done, the plot provides the NF value of the amplifier