Noise & gain measures from 2 to 18 GHz with Eaton 2075 & HP 8971b and adds


DATA ENTRY
POWER
POWER LEVEL
SLOPE
CW FILTER
RF OUTPUT
CAL
X-BAND SUPER LOW NOISE AMPLIFIER

Overview

- This 2nd Powerpoint is illustrating hits and kinks about gain and NF measurements **OVER 2 GHz** with both Eaton 2075a and HP or Agilent 8970a analysers.
- Solutions are covering the 2 – 18 and up to 26 GHz band

PART 2

MEASUREMENTS WITH EXTERNAL MIXER

Abstract

1- The solutions in the industrial world:
- **HP-8971b or c NF extension test-set**
- **Eaton NGA frequency extender**

2- Direct low-cost DSB measurements using a single broadband mixer

3- X, Y and Z outputs to an oscilloscope

4- Calibration of unknown noise sources from 2 to 18 GHz

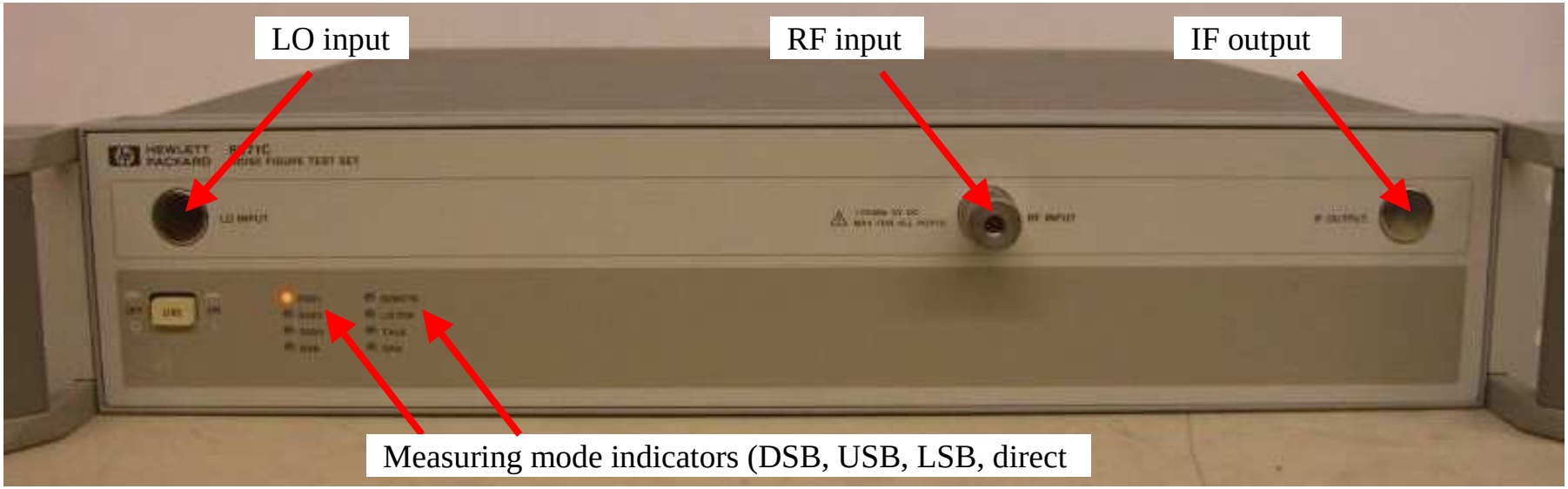
5- Conclusions

1- The solutions in the industrial world

The choice in the industrial world

Agilent HP 8971b (or c model) noise figure test-set

- Model b goes up to 18 GHz and c, up to 26 GHz
- 2 HPIB cables needed between analyser, extention and sweep

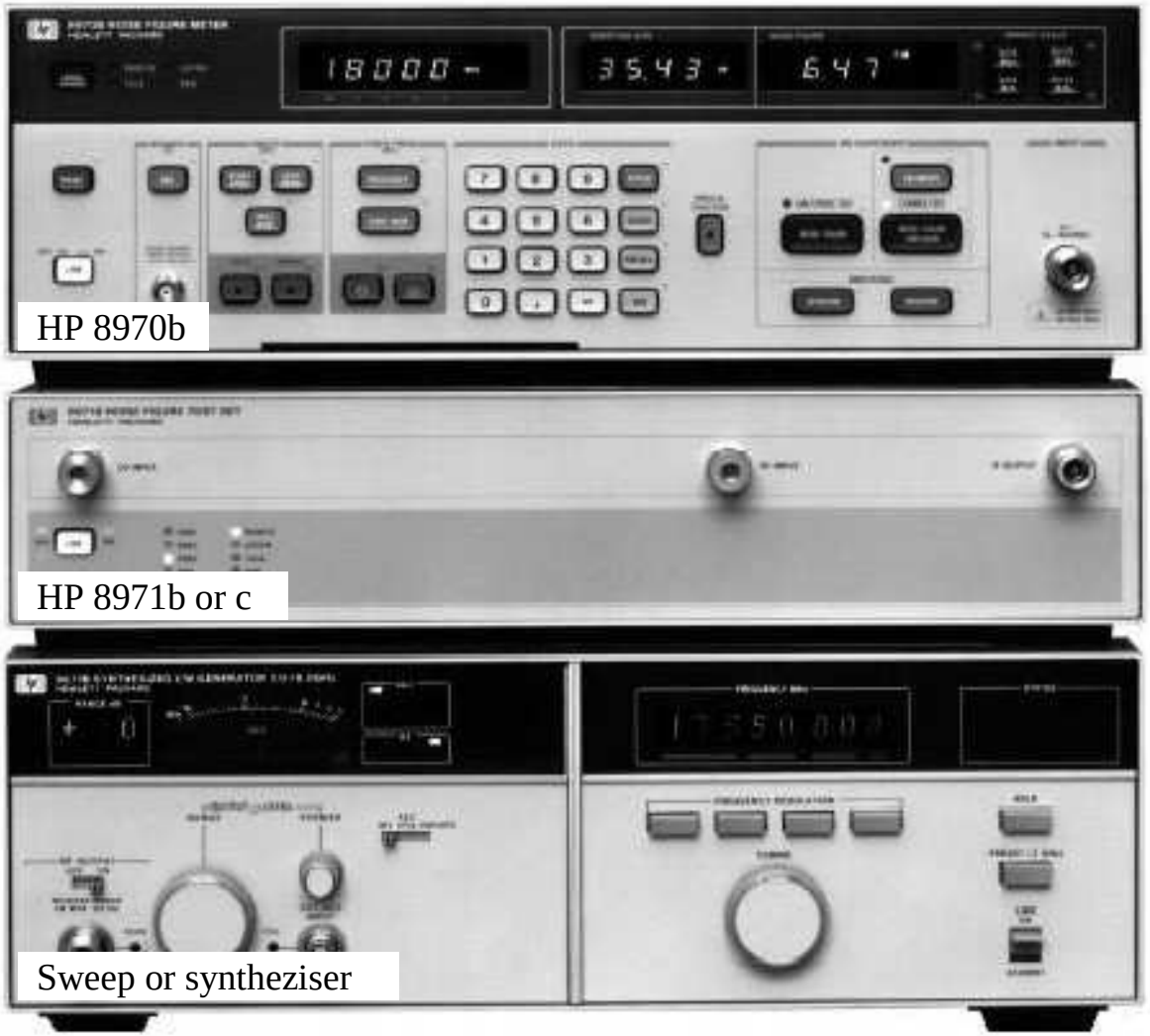


It's principally constitued by:
- a YIG following filter with HPIB tracking software
- an RF front-end broadband preamp
- a broadband mixer

Operation Modes:
- Band 1 - SSB1 (10-1600 MHz) using HP 8970b internal mode
- Band 2 - SSB2 (1601-2400 MHz, 700 MHz IF)
- Band 3 - SSB3 (2401-18000 MHz, 450 MHz IF)
- Band 4 - DSB (2401-18000 MHZ, 10 MHz IF)

The choice in the industrial world

Agilent HP 8971b (or c model) noise figure test-set



HP 8970T Noise Figure Measurement System (10MHz to 18 MHz).

The choice in the industrial world

Agilent HP 8971b (or c model) noise figure test-set

- Not supported by the HP 8970a model !
- In the figure, replace preamp + mixer by the NF test-set (+ additional Yig tracking filter)

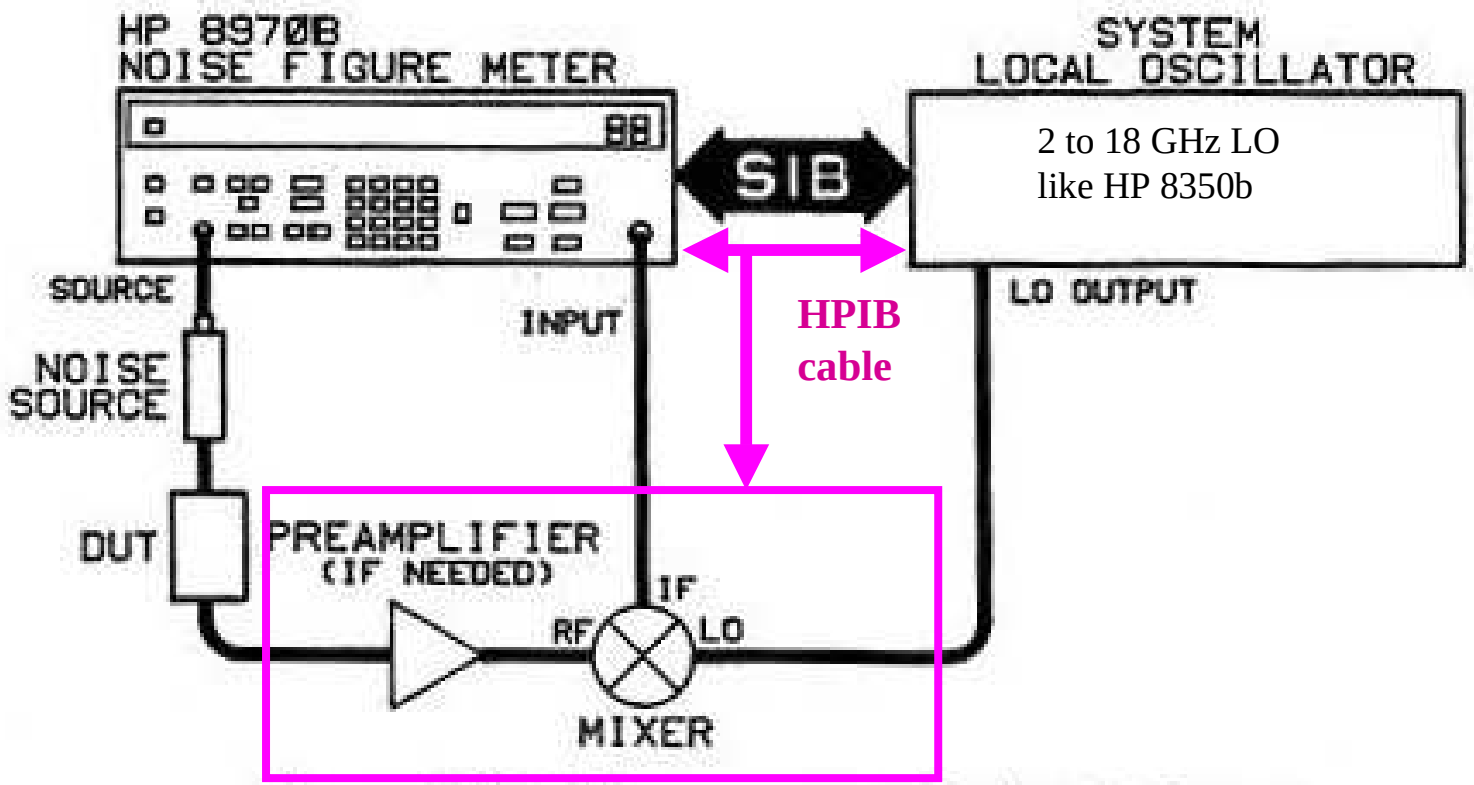


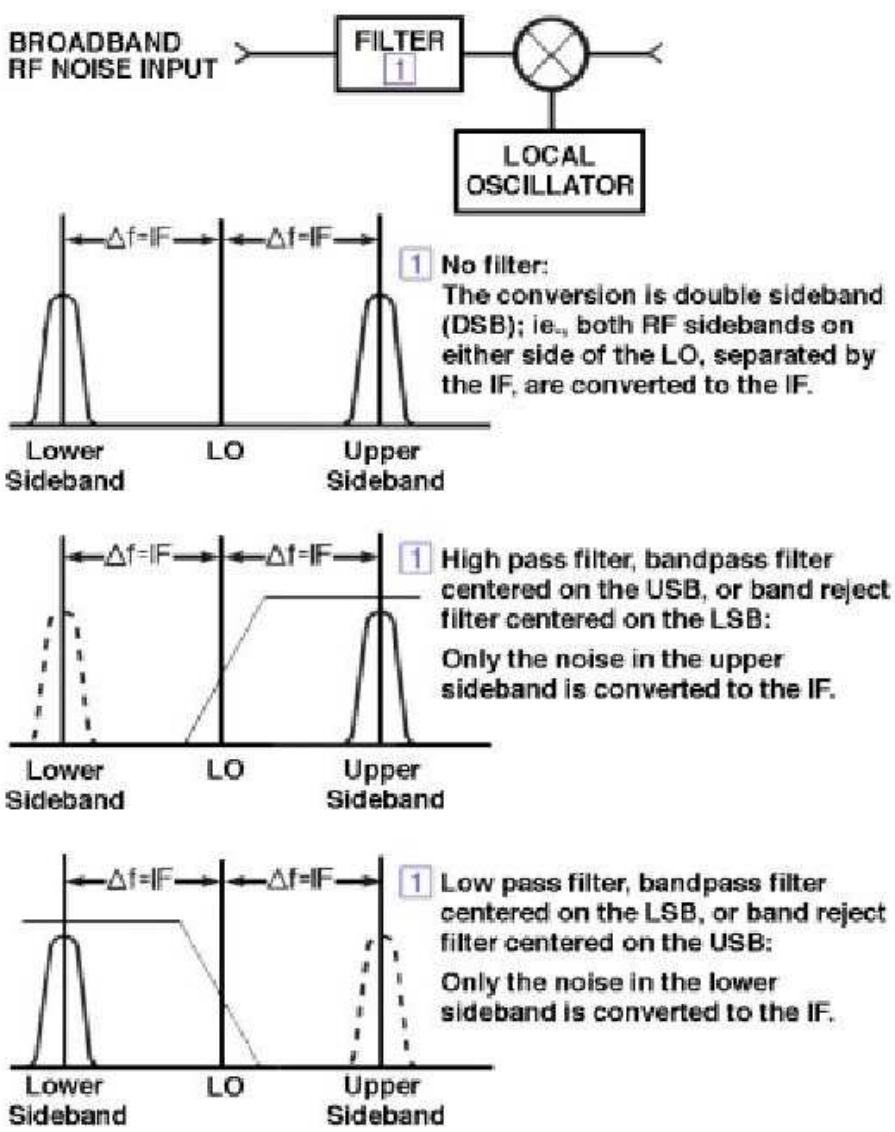
Figure 3-22. Measurement Mode 1.1 Setup

Configuration mode 1.1 choice = DSB mode with variable RF, external variable LO, fixed LO

The choice in the industrial world

Agilent HP 8971b (or c model) noise figure test-set

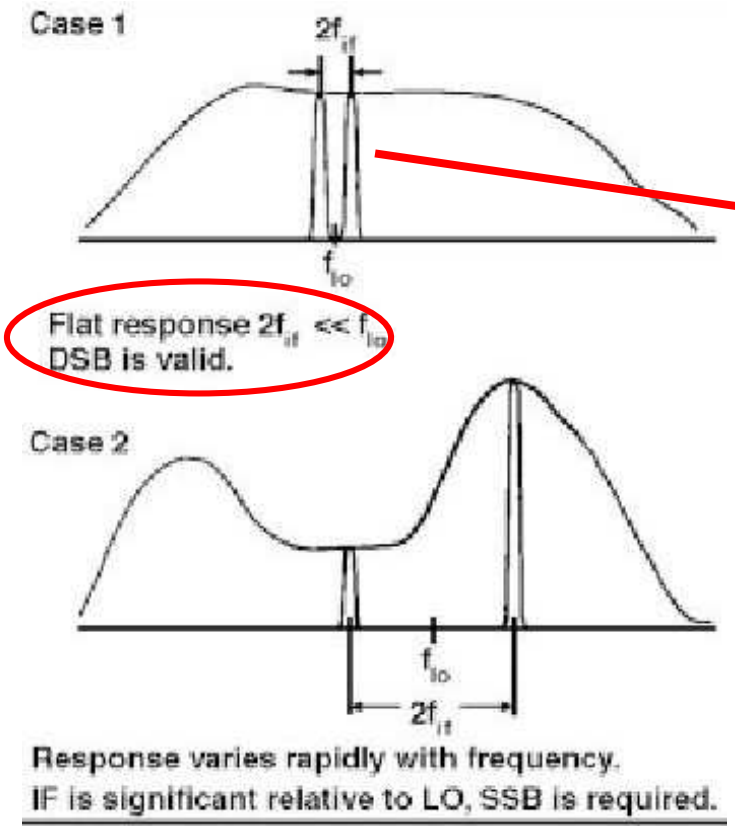
DSB or SSB mode

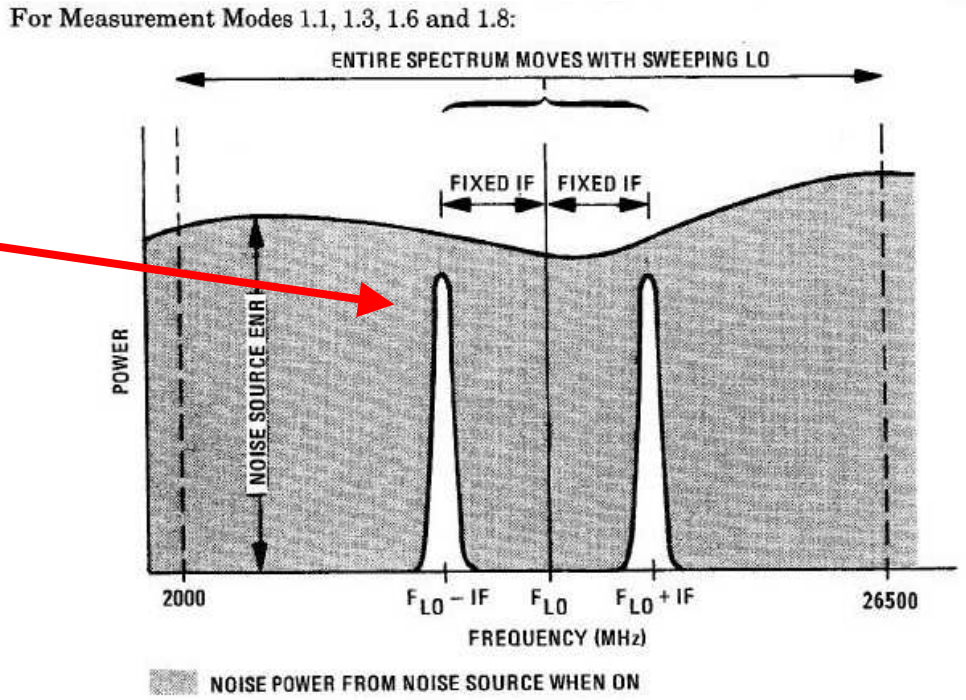


The choice in the industrial world

Agilent HP 8971b (or c model) noise figure test-set

- With relatively broadband amps, the DSB mode is preferred
- In this case the error between DSB and SSB mode is little, because IF signal of equal strengths
- No need of additional filter or preamplifier

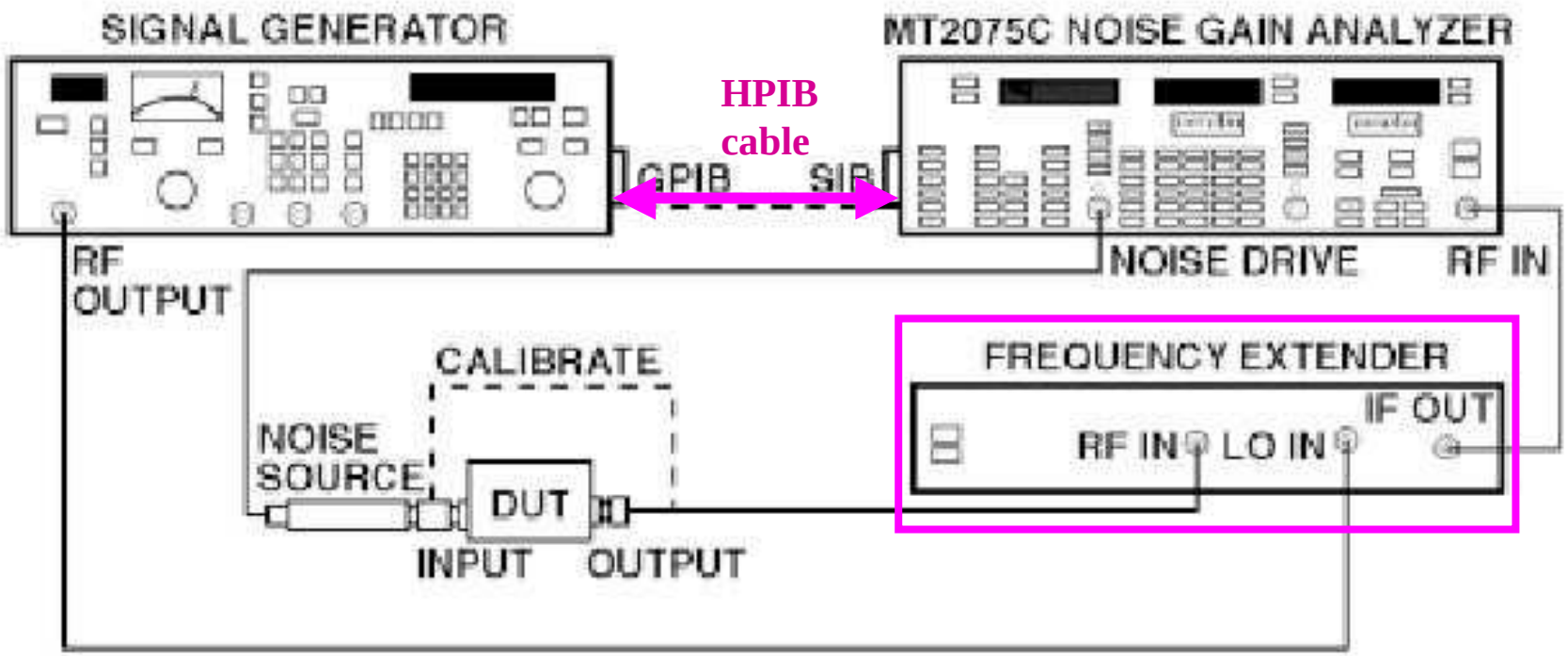




The choice in the industry

Eaton (Maury) MT 7550 series noise gain analyser frequency extender, up to 29 GHz

The choice of only DSB mode measurements possibility gives a design with :
- no internal tracking filter
- no HPIB tracking requirement, only between analyser and sweep generator
- no need of additional filter, only a broadband preamplifier
- far cheeper to build and align



The choice in the industry

Eaton (Maury) MT 7550 series noise gain analyser frequency extender

3 models choice according to the frequency domain

Model	Frequency Range GHz	Conversion Mode	
MT7550A	1.6 — 4.2	Single Sideband	
MT7551B	1.8 — 18.0	Double Sideband	→ **no inside filter !**
MT7552B	1.8 — 26.5	Double Sideband	→ **no inside filter !**

Great advantage : full compatibility with :
- all Agilent/HP sweeps 9350a or b series - - or sweep synthesiser
- all Maury/Eaton or Agilent/HP noise/gain analyser

The choice in the industry

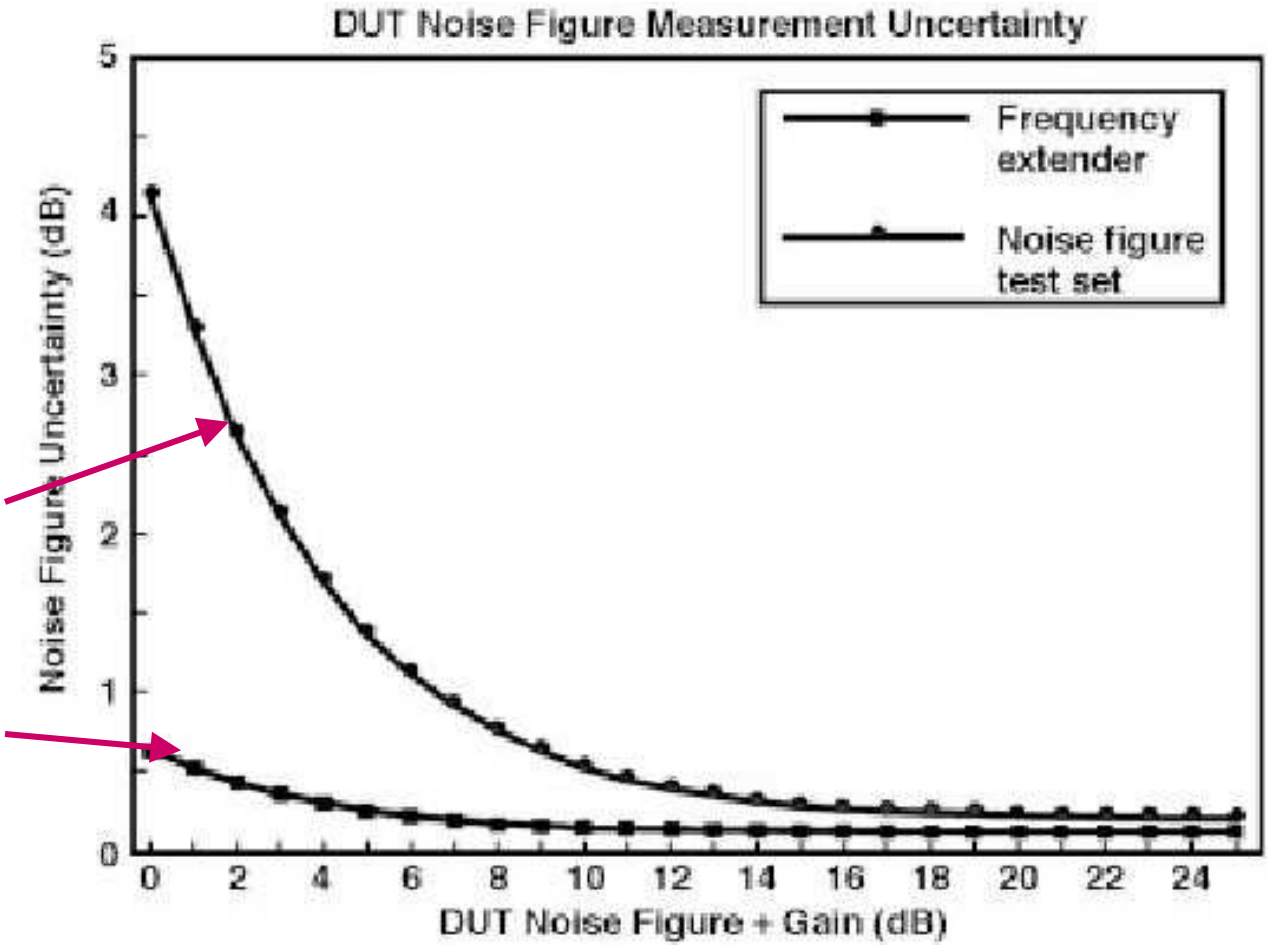
Comparaison between Agilent/HP and Eaton/Maury designs

	HP test-set	**Eaton extender**
Compatibility	Only with HP 8970b version	**With all HP & Eaton versions**
NF uncertainity at 2 GHz	Greater at low frequencies	Lower
DSB and SSB possibility	Yes	No
Price	« Expansive »	Far lower
2nd hand choice	Yes but expansive	Never found

The choice in the industry

Comparaison between Agilent/HP and Eaton/Maury designs

NF uncertainities compared between both extension brands (Eaton point of view)



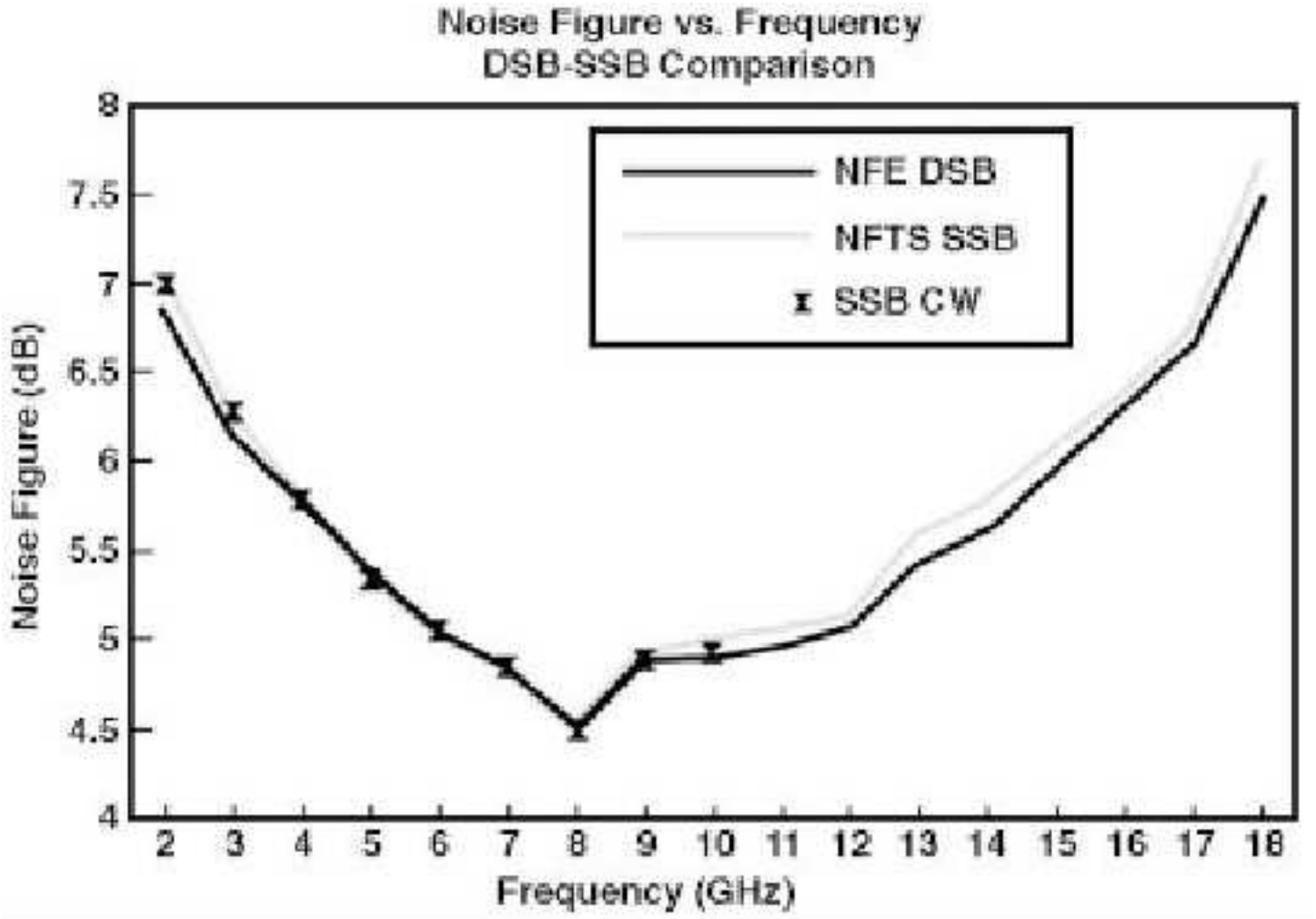
HP NF test-set

Eaton extender

The choice in the industry

Comparaison between Agilent/HP and Eaton/Maury designs

DSB and SSB measures comparaisons, according to Eaton



2- Direct low-cost DSB measurements on preamplifiers with only an external RF mixer and a sweep generator

Measurements at F>2 GHz with external mixer

Target : maximum gain & NF stability after 0 calibration with

- DSB option choice because microwave amps have a relatively broadband at high frequencies, in comparaison of the IF frequency taken for the meas **(like a 5.7 GHz preamp measured with a 70 MHz IF).**
- IF choice à 30 or 70 MHz - - so both IFs will sure have exactly the same power
- Choice of a double or preferably triple balanced mixer
- Care taking of optimal (not maximal) LO injection power for minimal insertion loss, between +7 to +13 dBm

- Older analyser versions like the HP 8970a or the Eaton 2075a can be used !
- Older sweep versions like the HP 8350a can also be used (not only the b version like with the HP NF test-set) !

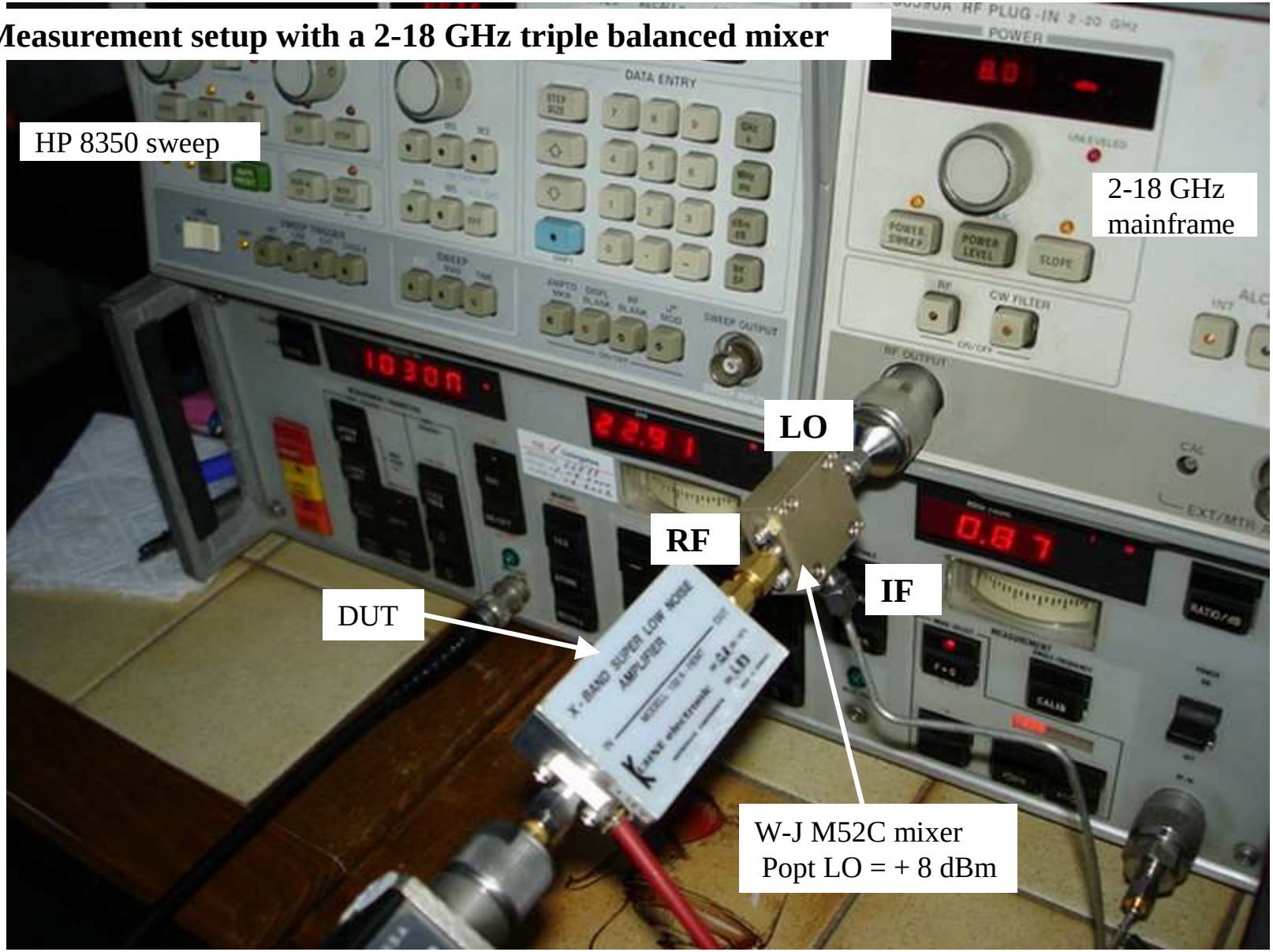
Examples of typical balanced SMA mixers (all tested):

Brand	Model	RF (GHz)	IF (GHz)	Balance	P LO opt (dBm)
Macom	MD-123	0.01-3	0.01-3	double	+10 to +15
W-J	M52C	2-18	0.1-4	triple	+10
W-J	M83C	1-18	0.03-5	triple	+13
W-J	M87C	0.5-19	0.03-5	triple	+13
Miteq	TB0218	2-18	0.5-8	triple	+10
Anaren	74129	5-18	DC-2.5	double	+12

W-J = Watkins Johnson

Measurements at F>2 GHz with external mixer

Measurement setup with a 2-18 GHz triple balanced mixer



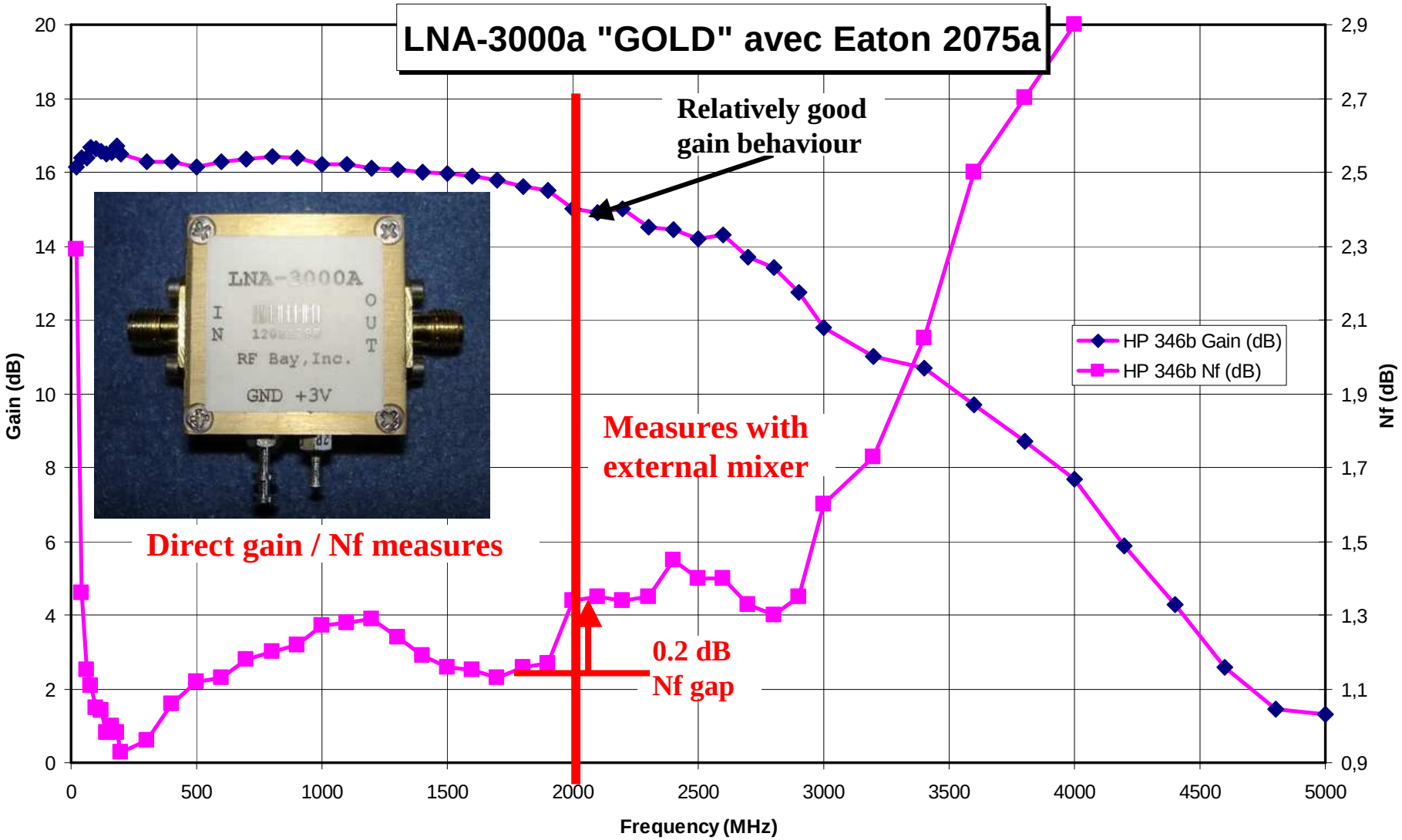
Measurements at F>2 GHz with external mixer

HPIB commands examples using either the HP or Eaton analyser

Gain/Nf measures in DSB with outside LO at frequencies > 2 GHz

With HP 8970a analyser					**HPIB analyser menu to enter**		*With Eaton 2075 analyser*		
	HP 8970a master							Eaton 2075 master	
	HPIB cable							HPIB cable	
	HP 8350a ou b slave sweep default address 8							HP 8350a ou b slave sweep default address 8	
page 3-70	1,1	**SP**	LED Local Talk "on"		**Var RF, ext LO, fixed IF**		**SP**	1,2	**Enter**
Start	6000	**Enter**			**Start 6 GHz**		**Start**	6000	**Enter**
Stop	12000	**Enter**			**Stop 12 GHz**		**Stop**	12000	**Enter**
Step size	100	**Enter**			**Step size**		**Step size**	100	**Enter**
					= DSB		**SP**	2,0	**Enter**
	41,0	**SP**			**Drives the HP 8350a or b sweep**		**SP**	47,3	**Enter**
	4,1	**SP**			**Takes the HP 8350a control**		**SP**	40,2	**Enter**
	3,0	**SP**	70	**Enter**	**Fixed IF of 70 MHz**	**Shift**	**Start**	70	**Enter**
Sweep HP 8350		**Pwr lvl**	6	**dBm**	**P LO = +6 dBm**		**Shift**	↑ 6	**Enter**
	19,1	**SP**			**IF cal**		**SP**	33,0	**Enter**

Measurements at F>2 GHz with external mixer

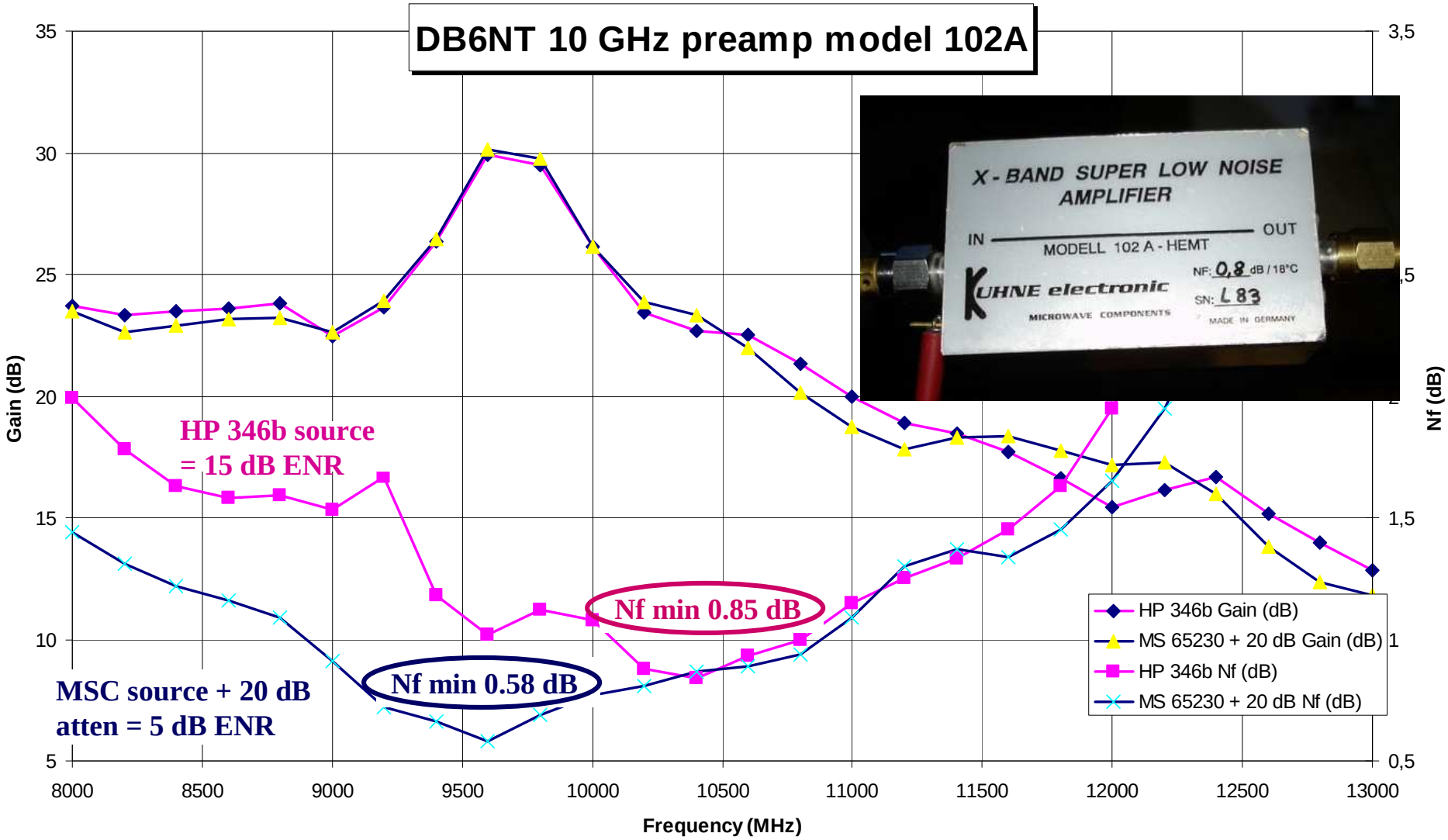


Measurements at F>2 GHz with external mixer

Good and safe comportment on scalar analyser (S11 always positive)

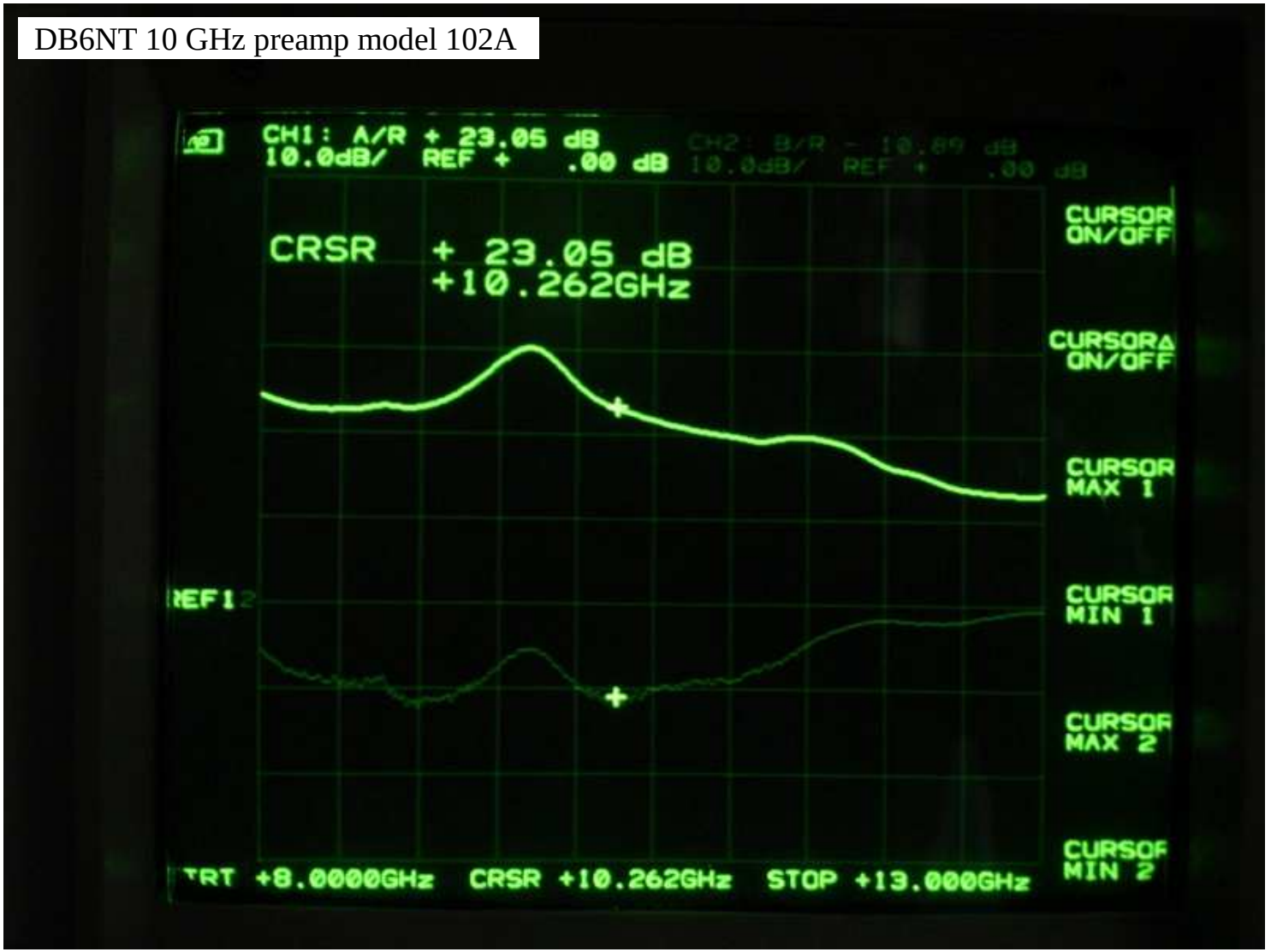
Measurements at F>2 GHz with external mixer

ENR value influence on precision measurements



Measurements at F>2 GHz with external mixer

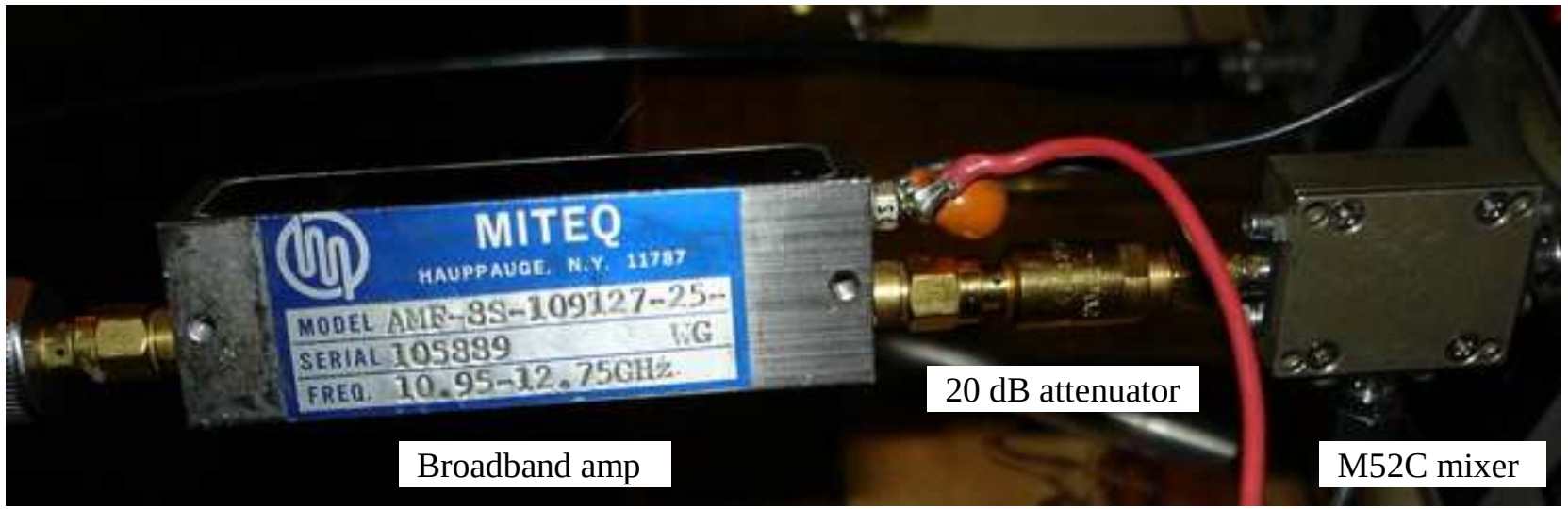
Good and safe comportment on scalar analyser (S11 always positive)



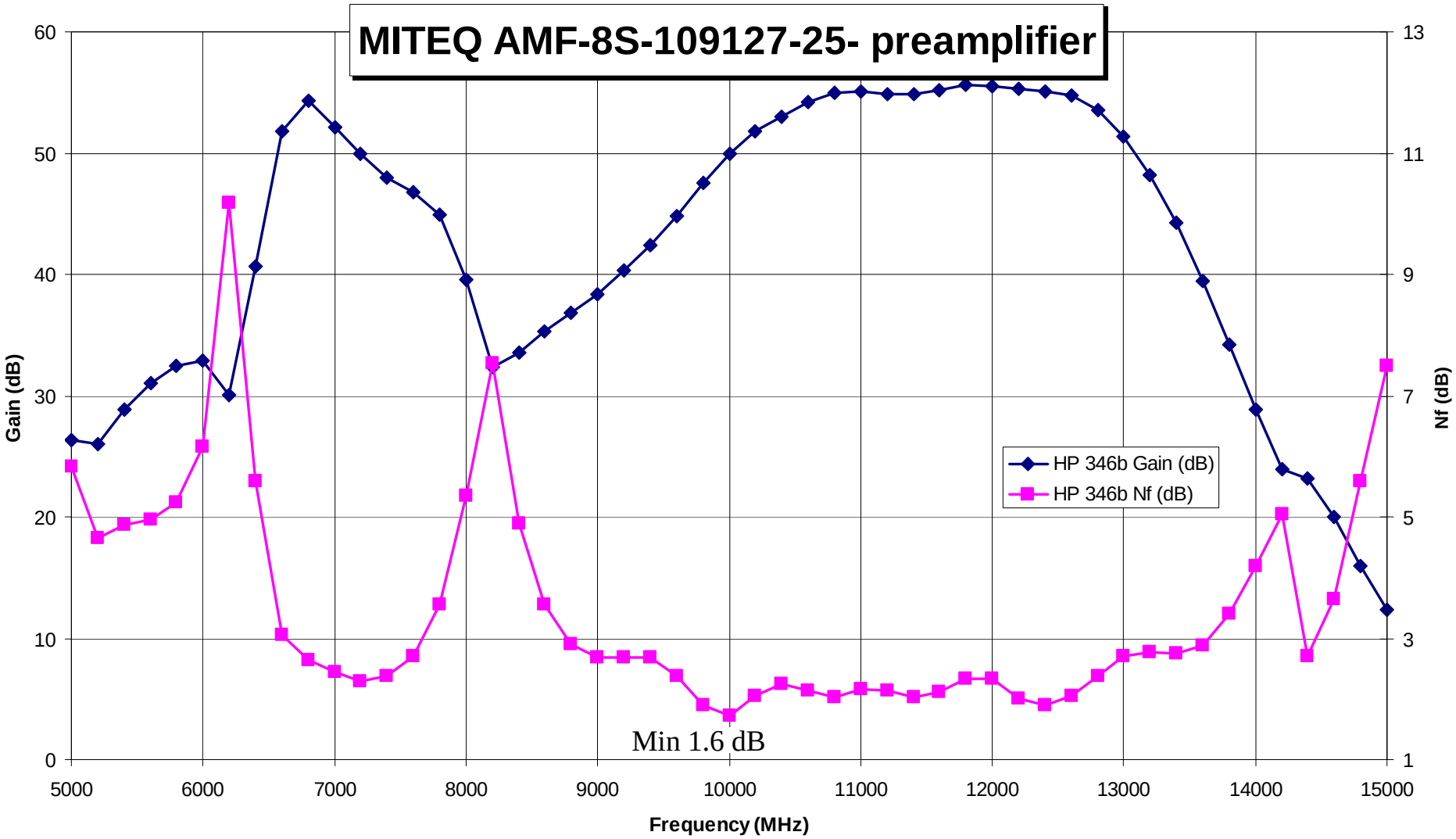
Measurements at F>2 GHz with external mixer

Measurement of a 50 dB gain broadband amplifier

- Because of its too high measured gain, a 20 dB attenuator is put at its outside.
- So an additional 20 dB **loss after DUT** must be entered into the analyser menu.



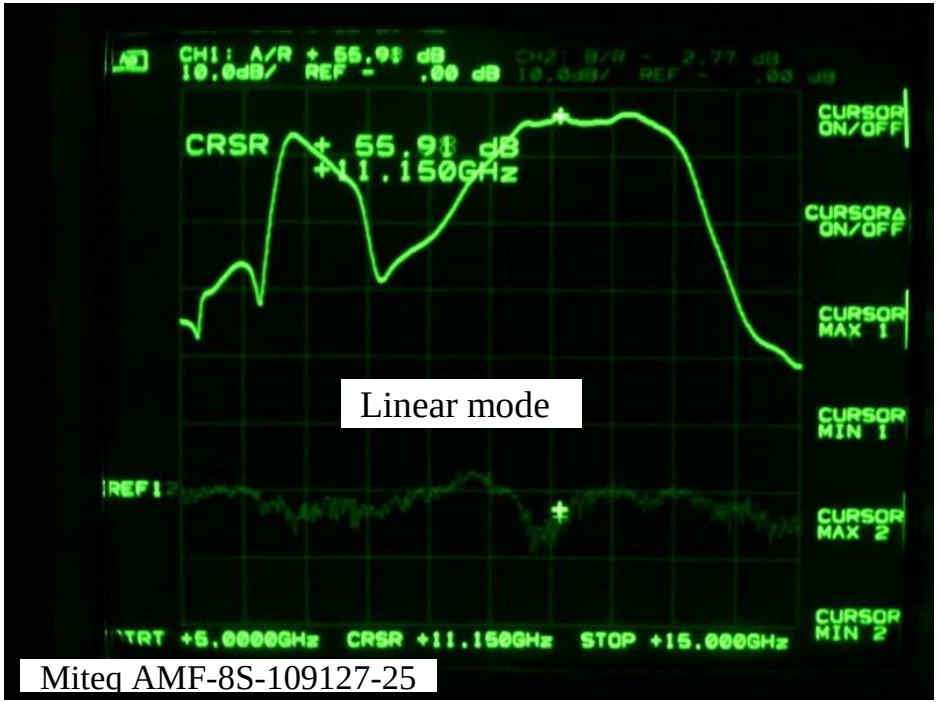
Measurements at F>2 GHz with external mixer



Measurements at F>2 GHz with external mixer

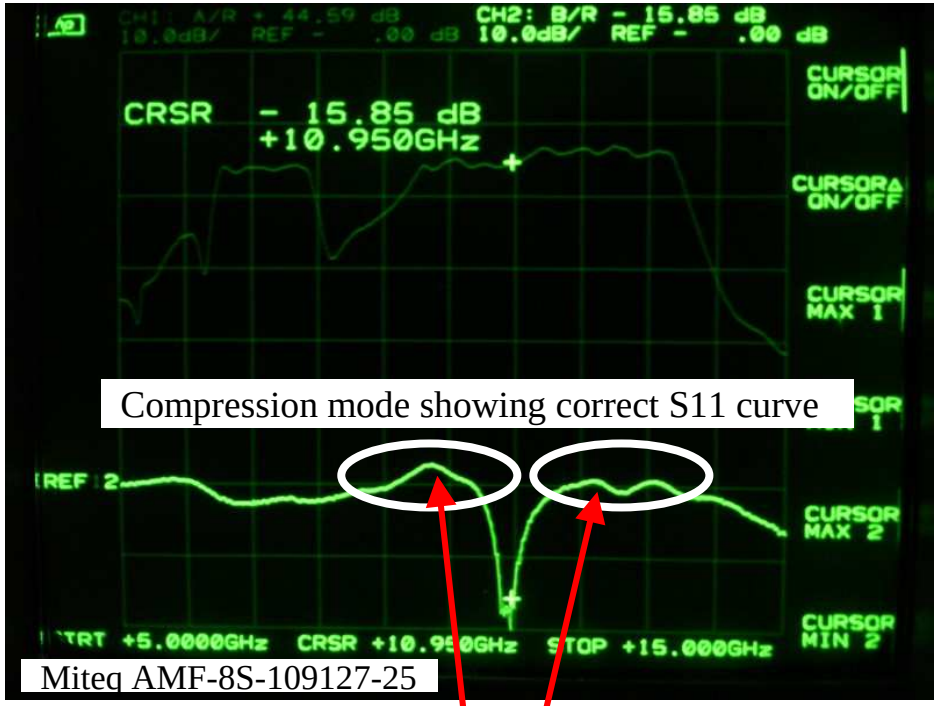
Comportment on scalar analyser, especially for its S11 curve

Miteq AMF-8S-109127-25 preamplifier



Linear mode

Miteq AMF-8S-109127-25



Compression mode showing correct S11 curve

Miteq AMF-8S-109127-25

S11 slightly positive and suspicious !!

Calibrating or oscillation beginning problems ?

GAIN : compare both values obtained with gain/NF and scalar analyser !!

3- X, Y and Z outputs on an oscilloscope

X, Y and Z outputs on an oscilloscope

One point NF measure or broadband gain + NF curves ?

- Doing only NF measurements at one fixed point in a ham band has **NO SENSE** !

- The great gain obtained on our masthead preamps can conduct to auto-oscillation

- Example: on a scalar analyser, look the S11 at its max gain ! You'll be estonished to see how it can approach the zero value, and in certain cases, be a little positive !!! That becomes easily an oscillator !

- If the temperature goes about 40°C down (from summer to winter), many masthead preamps are very easy oscillating !!!

- In order to feel how your (pre)amplifier is working, the only way to know it is to visualise in BROADBAND operation the regularity of both GAIN AND NF curves (french word = monotone) !!!

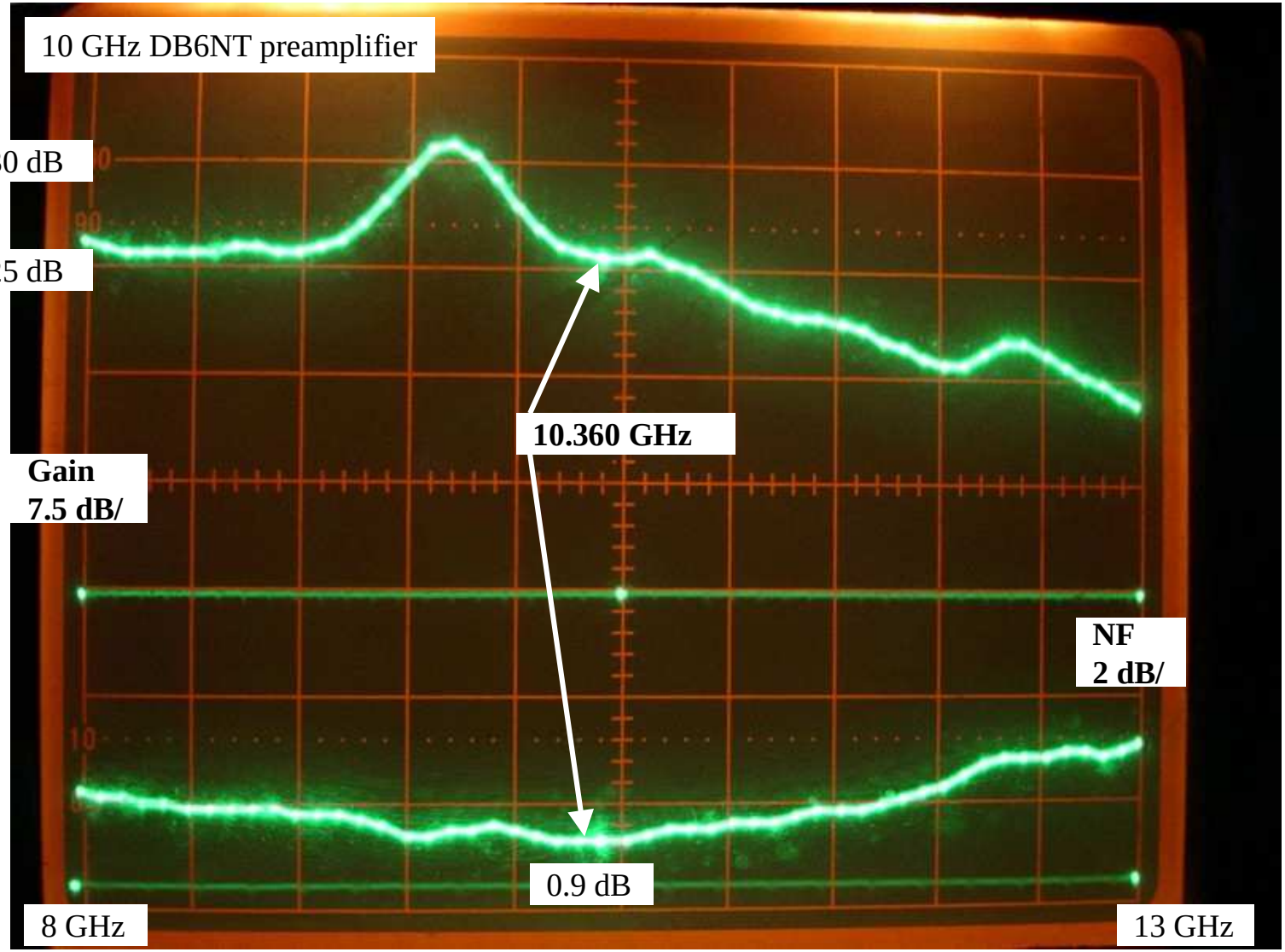
- Both HP and Eaton analysers have the three X, Y and Z output possibility to visualise this.

X, Y and Z outputs on an oscilloscope

Philips PM 3209 using the <u>X defl</u> possibility on its time base

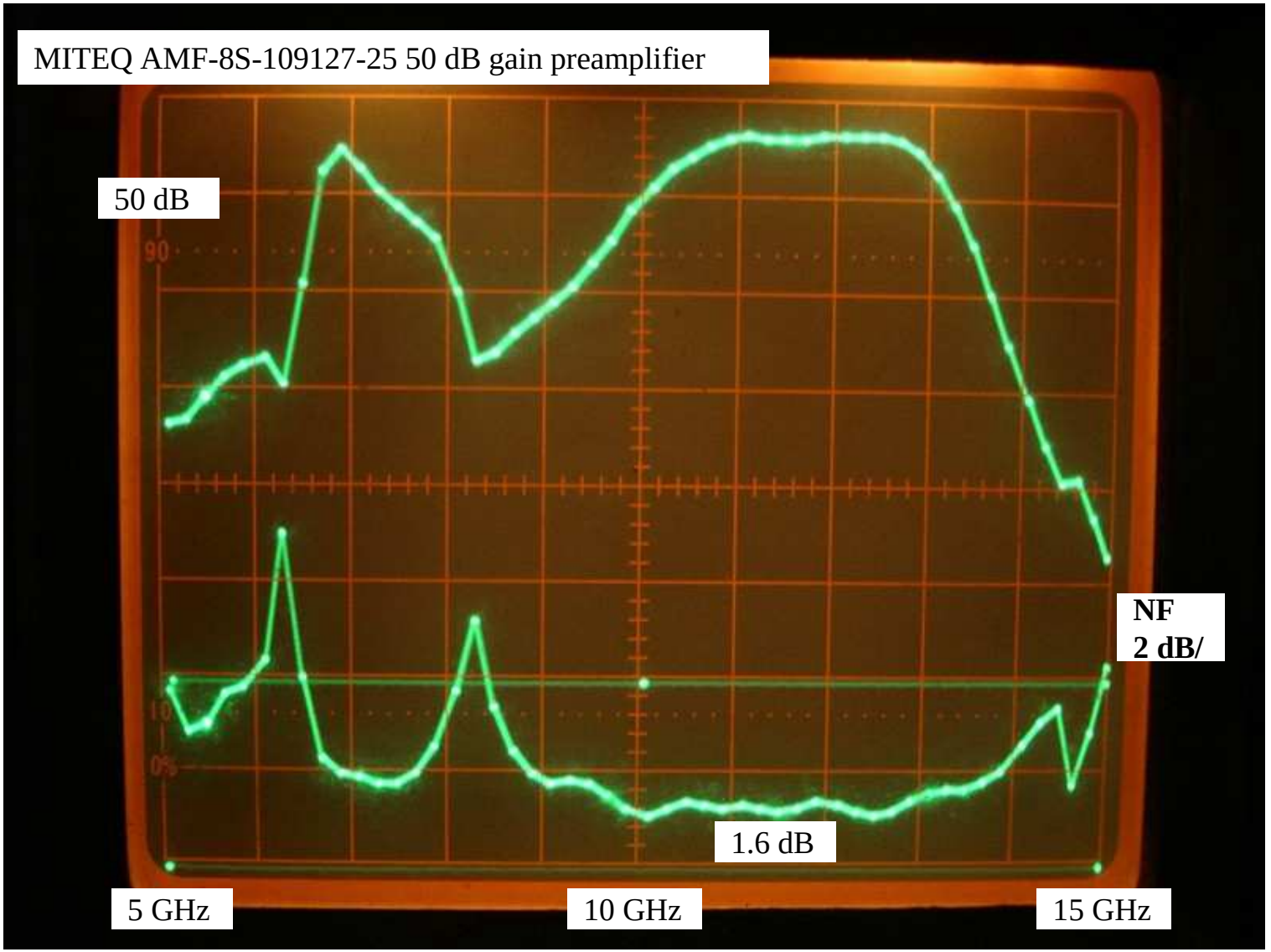
X, Y and Z outputs on an oscilloscope

Philips PM 3209 using the X defl possibility on its time base



X, Y and Z outputs on an oscilloscope

Philips PM 3209 using the <u>X defl</u> possibility on its time base

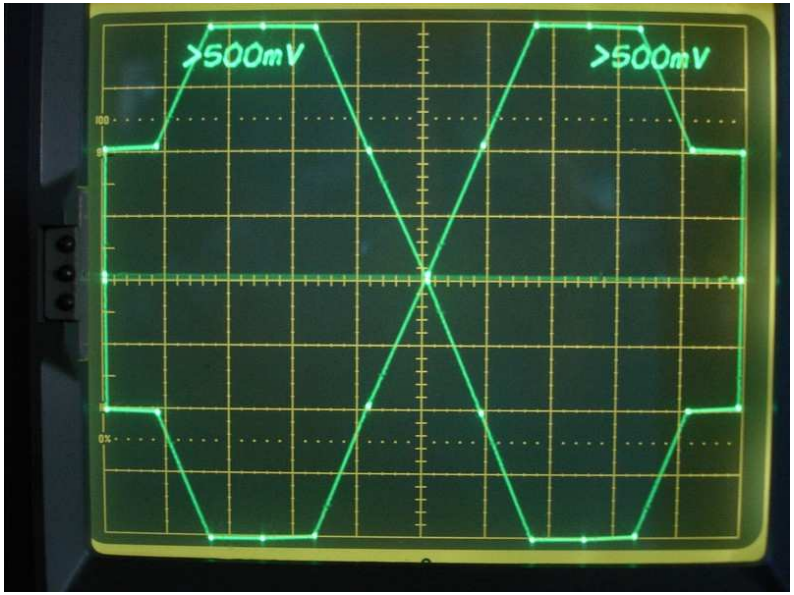


X, Y and Z outputs on an oscilloscope

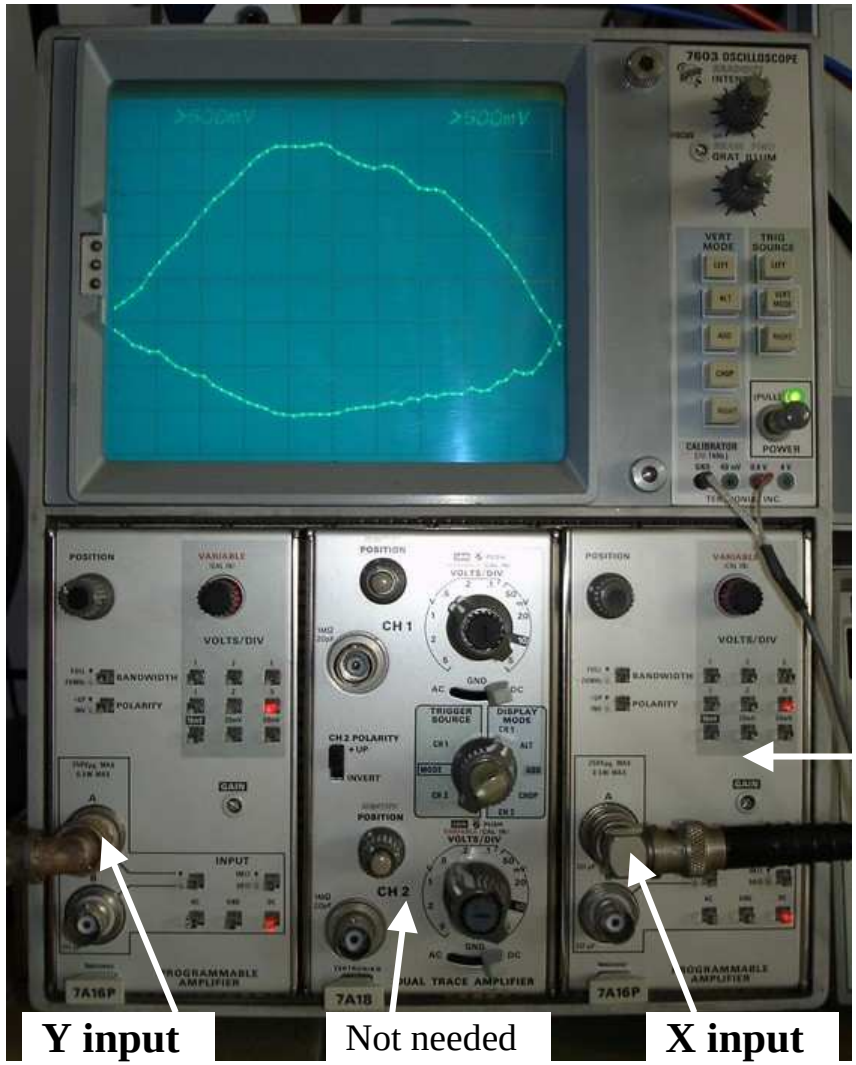
Tektronix 7603 using time-base and Y amplifier plugins

Its 7B80 time-base unit is replaced by a 2nd conventional Y amplifier 7A16 or 7A18 module (thanks to F6BSW for this trick)

Substitution only possible with oscilloscope mainframes accepting plugins !



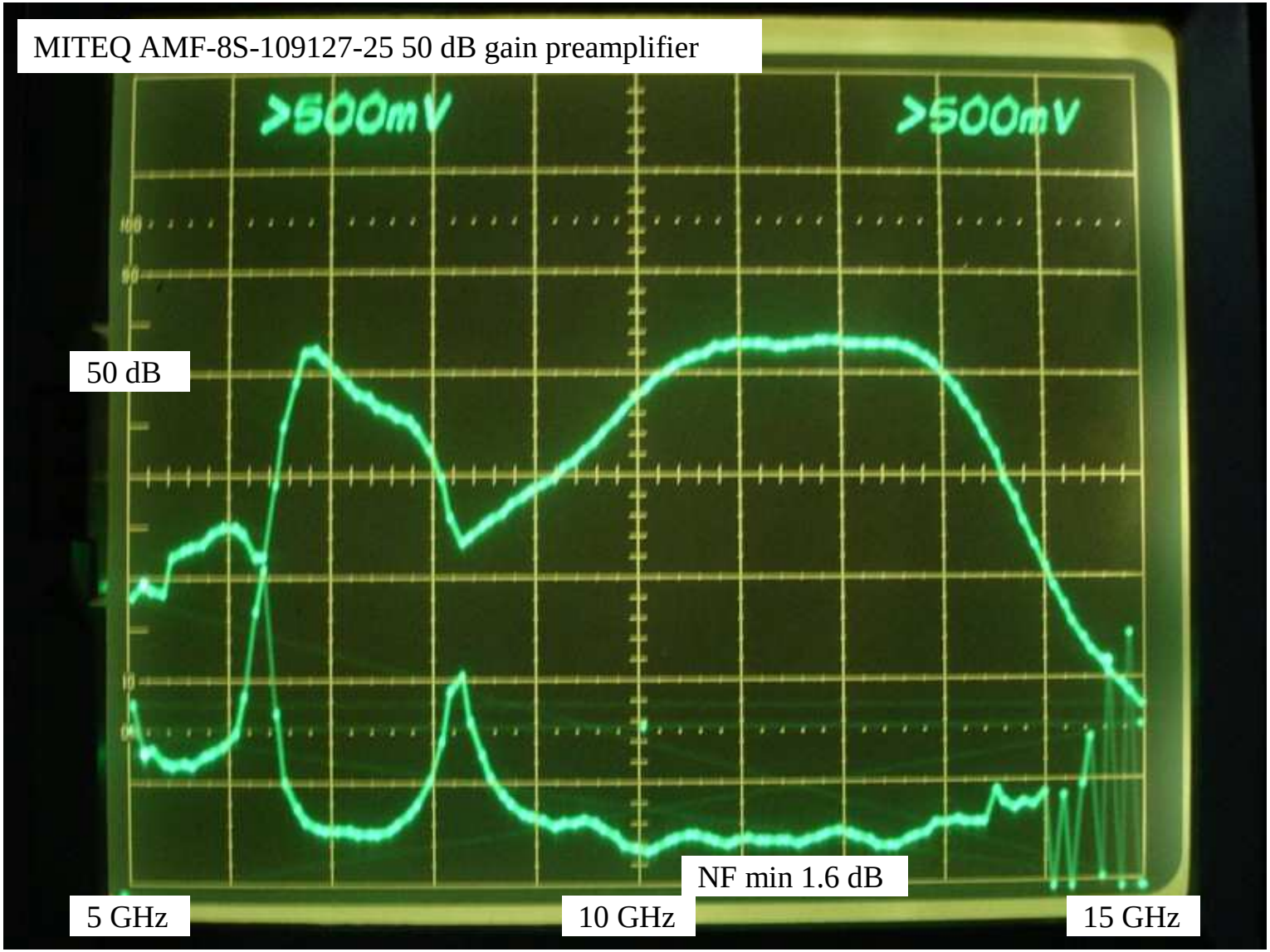
Initial test pattern obtained with :
- SP 7.2 « Enter » on Eaton 2075
- 7.1 SP on HP 8970



2nd Y amp instead of time-base

X, Y and Z outputs on an oscilloscope

Tektronix 7603 using time-base and Y amplifier plugins



X, Y and Z outputs on an oscilloscope

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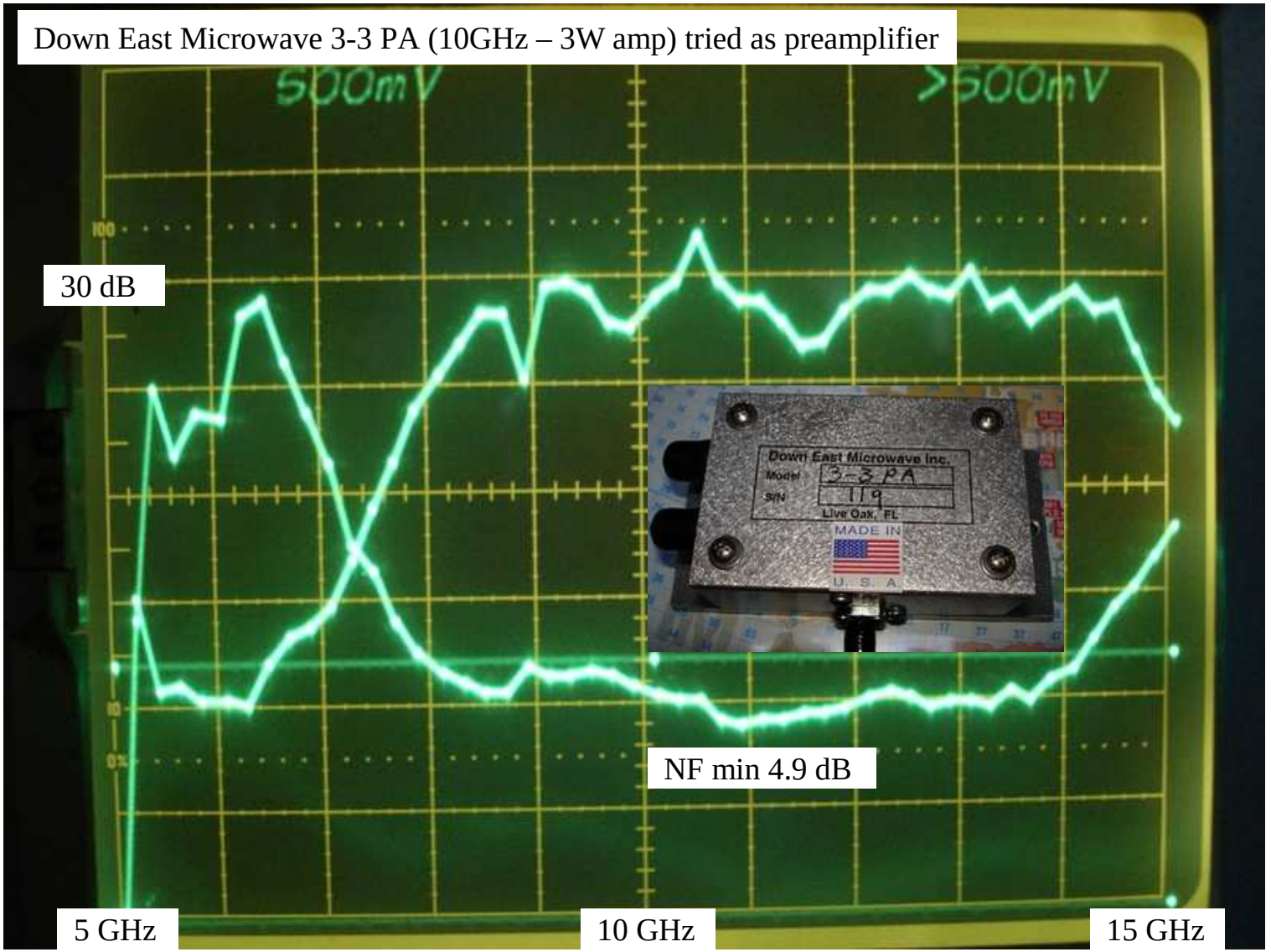

4- Calibration of unknown noise sources from 2 to 18 GHz

Unknown source calibration

Every 25, 15 or 6 dB noise source can be calibrated with a previous « gold » reference

F5DQK	longue	F5DQK	courte	F1PDX	
AILTECH	7616	**AILTECH**	7616	**MSC**	MS 65230
S/N	3710	S/N	3300	S/N	4173
21/01/2009		21/01/2009		21/01/2009	
F (MHz)	**ENR (dB)**	**F (MHz)**	**ENR (dB)**	**F (MHz)**	**ENR (dB)**
10	**6,65**	**10**	**14,7**	**10**	**24,19**
30	**12,64**	**30**	**16,14**	**30**	**25,38**
50	**13,94**	**50**	**15,59**	**50**	**24,83**
70	**14,47**	**70**	**15,69**	**70**	**24,98**
110	**14,78**	**110**	**15,83**	**110**	**25,08**
150	**14,93**	**150**	**16,13**	**150**	**25,29**
430	**15,13**	**430**	**16,13**	**430**	**25,51**
1000	**15,28**	**1000**	**16,18**	**1000**	**25,52**
1300	**15,32**	**1300**	**16,23**	**1300**	**25,39**
1500	**15,34**	**1500**	**16,14**	**1500**	**25,3**
1900	**15,49**	**1900**	**15,84**	**1900**	**25,28**
2000	**15,16**	**2000**	**15,44**	**2000**	**24,98**
2300	**15,09**	***2300***	**15,49**	***2300***	**23,79**
3000	**15,07**	**3000**	**15,12**	**3000**	**24,58**
4000	**14,72**	**4000**	**15,32**	**4000**	**24,46**
5000	**14,61**	**5000**	**15,51**	**5000**	**24,72**
5600	**14,29**	***5600***	**15,29**	***5600***	**24,33**
6000	**14,36**	**6000**	**15,31**	**6000**	**24,47**
7000	**14,7**	**7000**	**15,52**	**7000**	**25,04**
8000	**14,68**	**8000**	**15,28**	**8000**	**24,91**
9000	**14,48**	**9000**	**15,28**	**9000**	**24,76**
10000	**15,43**	**10000**	**15,53**	**10000**	**24,7**
10360	**15,58**	***10360***	**15,23**	***10360***	**24,42**
11000	**15,48**	**11000**	**15,13**	**11000**	**23,88**
12000	**15,05**	**12000**	**14,9**	**12000**	**23,97**
13000	**15,78**	**13000**	**15,23**	**13000**	**24,06**
14000	**14,75**	**14000**	**13,75**	**14000**	**23,3**
15000	**14,93**	**15000**	**15,58**	**15000**	**23,18**
16000	**14,31**	**16000**	**13,31**	**16000**	**23,46**
17000	**14,44**	**17000**	**14,39**	**17000**	**24,72**

DIRECTLY !

EXTERNAL MIXER !

Multipoint calibration also at every GHz

Calibration of a totally unknown MSC source

5- Conclusion

Conclusion

- For conventional ham purposes (large band microwave preamps and also transverter), DSB measures are giving largely enough accuraty
- According to the band of interest, the mixer choice must be carefully done
- The LO power injection must be chosen for minimal conversion loss
- No need of extra expansive NF test-set or frequency extender
- No need of an additional broadband amplifier
- Both oscilloscope gain and NF traces are useful to immediately thumb-up oscillating problems
- A complementary scalar analysis can confirm the linear gain and may also thumb-up oscillations beginning problems
- And in opposite way, a single gain / NF measure at only ONE frequency has **absolutely NO SENSE !**
- 2 to 18 GHz calibration of unknown noise sources can be easily achieved

Special thanks to F6FTN, F5BQP, F6BSW, F6DPH, F6AJW and F1PDX for their very useful help