The Challenge of LNA`s for 10 GHz

HB9BBD
Introduction

- Much has been written on the value of NoiseFigure at EME conferences, in Dubus etc.
- Still, it’s the difference between Noise and Signal which really matters
- It’s not what’s printed on the box, but what’s inside which makes the challenge
- The benchmark for HM LNA is clearly DB6NT
- Hypothesis: It should be possible to build a Band LNA, unconditionally stable, NF<0.8dB (averaged!), G>20dB
Agenda

- Don‘t trust the box, measure!
- The Benchmark LNA by DB6NT
- The Gang challenging the Leader
- Building the LNA
- Selecting the Device
- Measuring Noise and Gain
- The Results
- Appendix
What the Market keeps telling us..

The Components alone cost more!

0,1 dB?

Bargain!
The Benchmark LNA

DB6NT, Michael Kuhne

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The Benchmark LNA

DB6NT
F = 0.7 dB & 18°C
G = 22 dB
R 100
239 €

Test gear at DB6NT
Agilent 8975A
N4000A

* Loss of adapter measured on p.50

Test gear of DB6NT
Measured by HB9BBD

Agilent 8975A
N4000A

Incl. SMA-WG adapter 0.08dB*

Measured by HB9BBD

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F5BUU + F6BVA challenging DB6NT

http://f1chf.free.fr/F5DQK/3_Preamplis_LNAs/Preamplis_10_GHz_DB6NT.pdf

Préamplis 10 GHz à entrée guide
F5BUU, Jean Claude  F6BVA, Michel

http://f1chf.free.fr/F5DQK/3_Preamplis_LNAs/Preamplis_10_GHz_DB6NT.pdf

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F5BUU + F6BVA challenging DB6NT
(F5DQK Publisher, LNA’s built by F5BUU and F6BVA)

http://f1chf.free.fr/F5DQK/3_Preamplis_LNAs/Preamplis_10_GHz_DB6NT.pdf
OK2AQ challenging DB6NT


Nízkošumové zesilovače pro 10 GHz a jejich měření

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EME a MW seminář 2014
Tři Studně, Duben 11-13, 2014
Prof. Miroslav Kasal

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PGP Public Key

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Miroslav Kasal (* 1947 in Litomysl, Czech Republic) graduated in communication engineering from the Faculty of Electrical Engineering, Brno University of Technology, in 1970. In 1984 he obtained his Ph.D. degree in metering engineering. He was the head of the NMR Department and Electronics Laboratory of the Institute of Scientific Instruments, Academy of Science of the Czech Republic (1991-2002). Since 2002 he has been with the Department of Radio Engineering, Faculty of Electrical Engineering and Communication, Brno University of Technology, initially as associate professor and since 2006, as professor. He is a senior member of the IEEE. He has authored or coauthored a number of papers in scientific journals and conference proceedings. Dr. Kasal received the Award of the Rector of the Brno University of Technology and together with his doctor students the SIEMENS Prize for research (2004). In 2007 prof. Kasal received the Prize for research of the Minister of Education of the Czech Republic.

Professional orientation
Microwave techniques, satellite communication, signal processing, scientific instruments.
OK2AQ challenging DB6NT

OK2AQ challenging DB6NT


EME a MW seminář 2014
Tři Studně, Duben 11-13, 2014
OK2AQ challenging DB6NT


0,962 dB

0,829 dB

0,852 dB

MGF4953A
OK2AQ is using Agilent 8975A and N4000A

NE3511S02

EME a MW seminář 2014

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So let's challenge them all!

Designing a low noise LNA
So let’s challenge them all!

Designing a low noise LNA
So let’s challenge them all!

Mechanical Dimensions in mm
Building the LNA

Making the PCB (Rogers 4003C 0.508mm)
Building the LNA

Making the body
Building the LNA

Making the body
Building the LNA

Assembling the PCB: Components are ready
Building the LNA

Assembling the PCB: Applying Solder Paste

Solder Paste (with Pb!) melting point at 179 deg. C
Building the LNA

Assembling the PCB: Placing the Components
Building the LNA

Pre-Heating the PCB

Heating plate at 164 deg. C for preheating the board
Building the LNA

„Reflow oven“ substituted by hand..

Hot Nitrogen at 350 deg. C
Building the LNA

Heating plate at 164 deg. C for preheating the board

Nitrogen at 350 deg. C.
Building the LNA

Some boards (almost) ready

The first Fet still to be selected

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Building the LNA

Manual „Reflow Oven“ of the poor man

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Selecting the best device

Various GaAsFet tested
Obsolete and discontinued GaAs-Fets of the 90ies..

Fujitsu Type Markings

Fujitsu Low Noise HEMT Identification

<table>
<thead>
<tr>
<th>COLOUR</th>
<th>FHX13LG/LP</th>
<th>FHX14LG/LP</th>
<th>FMM5701LG</th>
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<tbody>
<tr>
<td>PURPLE</td>
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<td></td>
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</tr>
<tr>
<td>RED</td>
<td>FHX04LG/LP</td>
<td>FHX05LG/LP</td>
<td>FHX06LG/LP</td>
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<tr>
<td>BROWN</td>
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<td>FHX40LG</td>
<td>FSX56LP</td>
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<td></td>
</tr>
<tr>
<td>GREEN</td>
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</tbody>
</table>

The gate lead is always the one with the sloping end

0.45 dB@12 GHz  0.75 dB@12 GHz
Selecting the best device

Later GaAsFets (already discontinued **)

- NE32484A **: 0.6 dB@12 GHz
- NE32584C: 0.45 dB@12 GHz
- MGF4919G **: 0.45 dB@12 GHz
- NE3210S01 **: 0.35 dB@12 GHz
- NE3511S02: 0.30 dB@12 GHz
- NE3512S02: 0.35 dB@12 GHz
Selecting the best device

A simple way to quickly select a device
Various GaAs-Fet tested

Again, don’t believe, **MEASURE!**
Selecting the best device

A NE3210S01 at work

The latest Test Fixture!

High tech tooth stick
Selecting the best device

A NE3210S01 looks good!

Agilent 8975A
N4000A
Selecting the best device

After the measurement things become obvious..
Measuring Noise and Gain

For reliable NF measurement averaging matters!
Measuring Noise and Gain

The Relevance of Measurement Results

Work done. While I was at lunch with my wife, 20,000 measurements were taken.

Where is the minimum Noise?

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The Results pull us down to physics..
The Results pull us down to physics..
Measuring Noise and Gain

HB9BBD # 1-V2.3

0.45 dB@12 GHz

Noise Match

Gain Match

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Measuring Noise and Gain

HB9BBD # 1-V2.0

0.45 dB@12 GHz
Measuring Noise and Gain

HB9BBD # 1-V2.2

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Measuring Noise and Gain

HB9BBD  # 2-V2.3

0.45 dB@12 GHz
Measuring Noise and Gain

HB9BBD # 4-V2.3

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Measuring Noise and Gain

HB9BBD # 3-V2.3

0.45 dB@12 GHz
The Results bring us down to reality..

HB9BBD 10 GHz LNA’s including WG/SMA Adaptor
SMA-WR75 adaptor considerations

Some Adaptors are perfect

Tuning screw out of center
SMA-WR75 adaptor considerations

Measuring the loss

Always use these blades!
They make a small difference!
SMA-WR75 adaptor considerations

Measuring the loss
SMA-WR75 adaptor considerations

S-Parameters S11, S22, S21 at a glance

-0,16 dB/2 = -0,08 dB
The Results bring us down to reality..

HB9BBD 10 GHz LNA’s without WG/SMA Adaptor

![NF & Gain in dB Graph]

Gain

Noise

dB

dB
Wrap-up

• On 10 GHz the State-of-the-Art NF is in the order of Noise@Device + 0,2 dB at ambient temperature
• The adapter SMA-WG adds some 0.08 dB ~
• There is no WG NoiseHead available anymore!

Therefore at best NF can be expected 0,60 dB (WG/SMA loss)
This is because all components including PCB are lossy and generate Noise.
• You can build your own LNA, if you are not much impressed by the time you invest and if your XYL is very tolerant.
• Do not expect wonders (from LNA!).
Questions? Comments?
SMA-WR75 and 60cm Flexible WG

S21 -0.2 dB net without Adaptors

-0.2 dB

-0.36 - 0.16 = -0.2 dB
Appendix

HP X347A Waveguide Noise Source

ENR 15.2 dB, not ideal for LNA
(obsolete)
Measuring Noise and Gain

Single stage (SMA/SMA) FHX13LG

0.45 dB at 12 GHz
Appendix

Some scrap…