DRILNA 144/432

New preamplifiers with extraordinary IM3 tolerance

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Agenda

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The Golden rule: «Lower NF»

- In weak signal communications the Mast mounted preamp is responsible to fix the signal to noise ratio (S/N)
- Lower the noise figure of the device more deep from the noise the signals can emerge

This create for years the «TOP» of the preamplifier design, searching the last 1/10 of dB in NF and create an industry of preamplifiers and techniques with no precedent in our hobby

40+ years of traditional preamplifers

1970s–1980s: Discrete GaAsFET Era

- The first serious EME preamps used discrete GaAsFET such as the NEC 3SK88 and later the MGF1302.

Characteristics:

- Noise figures around 0.5–1.5 dB depending on frequency.
- Simple single-transistor common-source circuits.
- Hand-tuned matching networks.
- Stability and repeatability were major challenges.

At that time, achieving a 1 dB noise figure on 432 MHz was considered excellent.

40+ years of traditional preamplifers

- **1980s–1990s: Golden Age of GaAsFET LNAs**

Devices MGF1402 , MGF1801, ATF10135 , ATF10136, became the standard for serious EME

- Improvements:
- Noise figures below 0.3 dB at 144 MHz
- Better gain and stability.
- More sophisticated input matching.
- Widespread use of cavity and bandpass filters.

Many world-record EME stations of the period used GaAsFET LNAs.

40+ years of traditional preamplifers

2000s: PHEMT Revolution

Pseudomorphic HEMT (PHEMT) technology transformed low-noise design.

Popular devices included ATF54143, ATF58143, MGA62563

Benefits:
Noise figures below 0.2 dB on VHF/UHF, Higher gain, easier broadband matching.
Better production repeatability.

For many EME stations, the sky noise rather than the LNA became the limiting factor.

40+ years of traditional preamplifers

2010s: MMIC Era

High-performance MMICs started replacing discrete FET designs.

Examples:
PGA103+
SPF5189Z
TQP3M9037
Advantages: Extremely simple construction, consistent performance, excellent gain and NF and Low manufacturing cost.

The focus gradually shifted from obtaining the lowest possible NF to optimizing overall system performance.

40+ years of traditional preamplifers

- **2020s: High-Dynamic-Range EME LNAs**
- Modern EME environments face a new challenge: strong man-made signals from Cellular towers, digital broadcasting, PV inverters, switching supplies, and communication systems can overload traditional LNAs.

- Design priorities changed:

Old philosophy: Lowest possible NF.

Modern philosophy: Very low NF BUT TOGETHER with Extremely high OIP3 and excellent input return loss to allow the use of ultra-low-loss bandpass filters ahead of the LNA.

40+ years of traditional preamplifers

Current state-of-the-art EME LNAs routinely achieve:

NF: 0.3–0.4 dB at 144 MHz.
OIP3: +35 to +45 dBm.
Input return loss: 20–30 dB.

Typical modern devices:

QPL9547
TQP3M9037
TQP3M9036

New mmic devices with high OIP3

	TQP3M9036	TQP3M9037	QPL9547
Operational BW	50 – 2000 MHz	0.7 – 6.0 GHz	0.1 – 6 GHz
GAIN	19.8dB @900Mhz	20.0dB @1.95GHz	19.5dB @1.90GHz
Noise Figure	0.45dB	0.4dB	0.3dB
OIP3	36dBm @900 MHz	35dBm @1.95GHz	39dBm @1.9 GHz
IRL (input return loss)	-13dB @900 Mhz	-11dB @1.95GHz	-13.2dB @1.9 GHz
IRL @144Mhz	-7.5dB	-7.4dB	-1dB
GAIN @144MHz	27.7dB	26.5dB	26.0dB

The IP3 “Trap”

For years preamplifier manufactures declare extraordinarily high numbers for IP3.

Well, because big numbers sales

The problematic is the absence of consistency to talk just “IP3” and avoid talking about IIP3 or OIP3, what really maters for a figure of merit is the IIP3 , NOT OIP3

One thing is declare IP3 = 39dB and another IP3 = 9dB

With that declaration people will buy the preamp with IP3 = 39 following the absurd rule of “big is better”

The IP3 "Trap"

How to detect the real numbers?

- As a rule of thumb, OIP3 fluctuates between 20 to 50dB when IIP3 is a much lower number depending on the gain, generally below 15dB

- IIP3 = OIP3 – GAIN

- If you find a preamp declaration like this one:
    - Gain: 28dB
    - NF: 0.3dB
    - IP3 : 32dB

Its clear the IP3 is in the reality OIP3, then apply the formula:

IIP3 = 32 – 28

The figure of merit by Third Order Interception point is
4dB AND NOT IP3 = 32dB

Practical comparisson

Disclaimer

I will compare the legendary MKULNA144 with the DRILNA144

The DRILNA144 is a high-linearity powerhouse. While the MKULNA144 is a legendary, high-quality TOP German-engineered LNA with a very competitive noise figure, the DRILNA144 is specifically designed to survive in high-signal environments where most other preamps would fail due to intermodulation.

Practical comparisson

Preamp	DRILNA144	MKULNA144
Gain	27.0dB	26.0dB
NF	0.38dB	0.40dB
OIP3	36dBm	24dBm
IIP3	8.3dBm	-2.0dBm
IRL	-30.0dB	-1.0dB

Practical comparisson

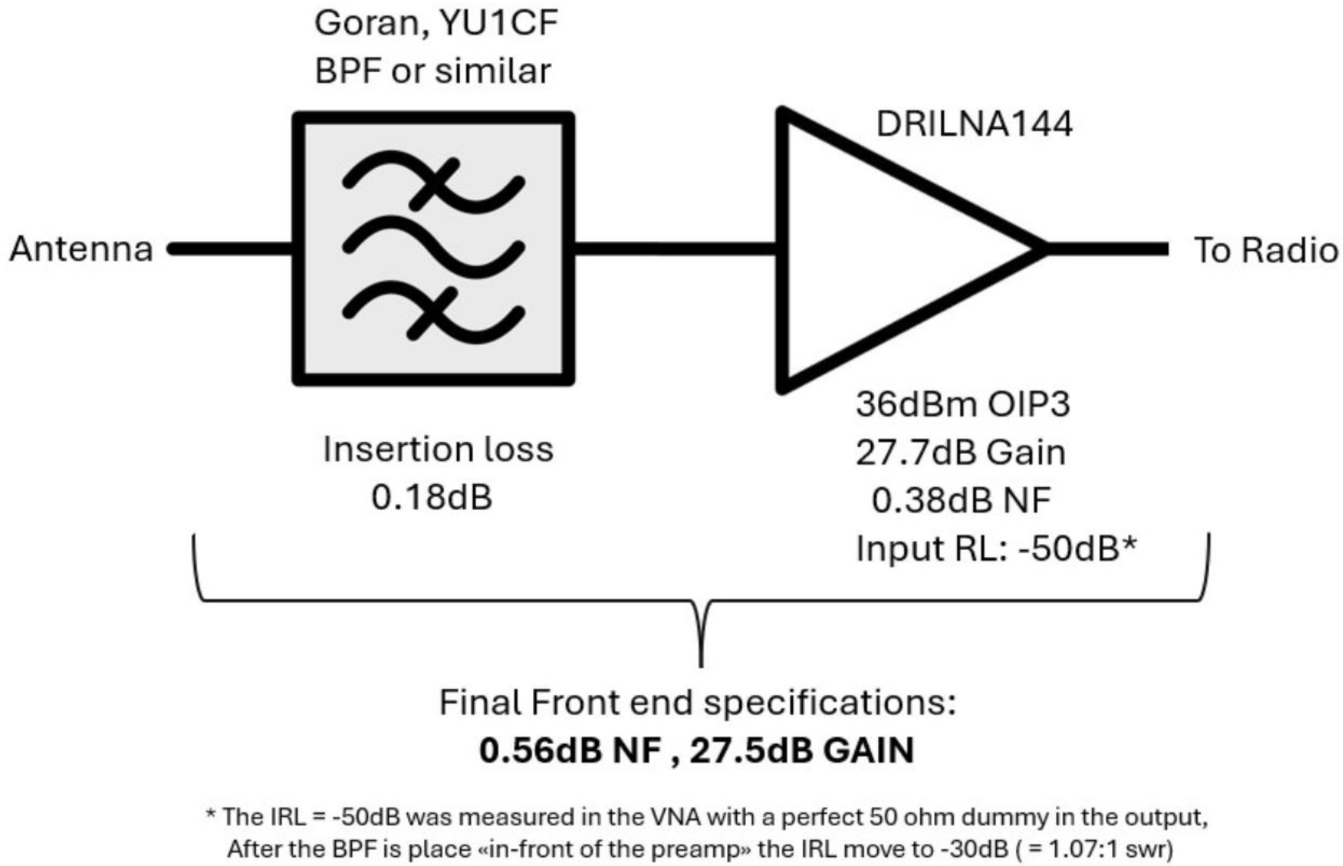
1.- 20.6 dB Reduction in "Garbage": Following the "2-for-1": when you improve the IIP3 of a system, the reduction in distortion is always double the increase in the IIP3 value, the DRILNA144 has 10.3 dB higher intercept point means its internal intermodulation distortion (the "phantom signals" created by strong neighbours) will be 20.6 dB lower than the MKULNA144 for the same input signal.

2.- Handling Strong Interference: If you are in an environment with strong local signals (like a nearby FM station or a crowded radio contest), the MKULNA144 will "choke" or produce audible distortion far sooner. The DRILNA144 can handle signals that are over 10 times more powerful (10^1.03) before reaching the same level of nonlinear behaviour.

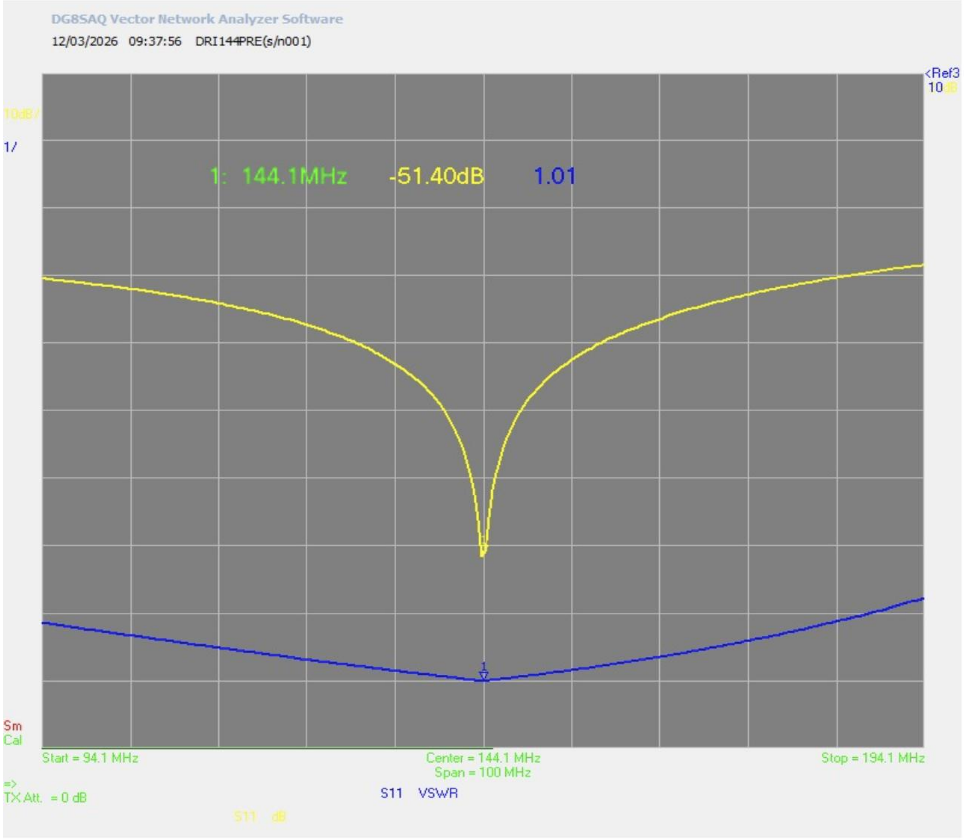
3.- Spurious-Free Dynamic Range (SFDR): The DRILNA144 expands your usable dynamic range by nearly 7dB. This is the difference between hearing a weak EME station and having it masked by "splatter" from a strong station a few kHz away

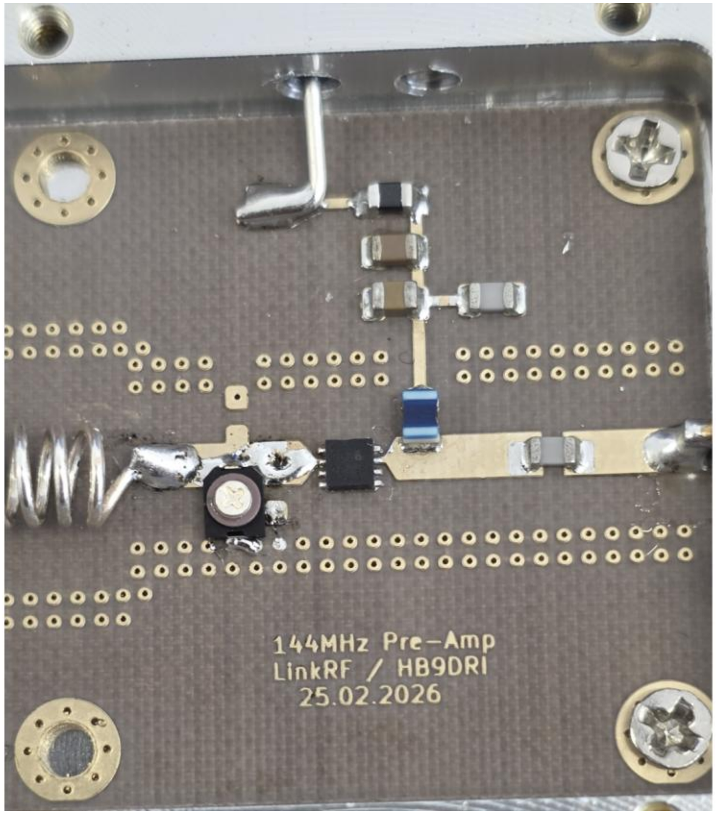
4.- The MKULNA144A remains a legendary piece of German engineering. But for the operator who demands the state-of-the-art in precision and linearity, the DRILNA144 is the new benchmark. It brings unprecedent IRL to the VHF spectrum allowing you to place a BPF ahead the preamp without destroying the BPF performance

The impensable solution



The impensable solution





Using the Sky temperature as an ally

1) Filter loss directly increases receiver noise figure

If a passive filter with insertion loss L is placed before the LNA, its noise factor is simply:

$$F_{filter} = L_{linear} = 10^{L_{dB}/10}$$

In Goran's filter that "noise factor" is:

$$L_{dB} = 0.18 \text{ dB}$$

$$F_{filter} = 10^{0.18/10} = 1.0423$$

In consequence the equivalent noise temperaure added by Goran's filter is:

$$T_{e,filter} = (F_{filter} - 1) \cdot 290$$

$$T_{e,filter} = (1.0423 - 1) \cdot 290 = 12.27 \text{ K}$$

Using the Sky temperature as an ally

2) Convert DRILNA noise factor into noise temperature:

The noise factor for the DRILNA will be:

$$F = 10^{NF/10}$$

$$F = 10^{0.38/10}$$

$$F = 10^{0.038}$$

$$F \approx 1.0916$$

and the Equivalent noise temperature will be:

$$T_e = (F - 1) \cdot 290$$

$$T_e = (1.0916 - 1) \cdot 290$$

$$T_e = 0.0916 \cdot 290$$

$$T_e \approx 26.56 \text{ K}$$

Using the Sky temperature as an ally

3) Total Front-end temperature and NF:

Front-end temperature in kelvin degrees:

$$T_{rx,total} = T_{e,filter} + L_{linear} \cdot T_{e,LNA}$$

$$T_{rx,total} = 12.27 + 1.0423 \cdot 26.6$$

$$T_{rx,total} = 12.27 + 27.74$$

$$T_{rx,total} \approx 40.0\ \mathrm{K}$$

Using the Sky temperature as an ally

Total fron-end (BPF+DRILNA) Noise figure in dB:

$$F_{total} = 1 + \frac{T_{rx,total}}{290}$$

$$F_{total} = 1 + \frac{40.0}{290} = 1.1379$$

$$NF_{total} = 10\log_{10}(1.1379)$$

$$NF_{total} \approx 0.56 \text{ dB}$$

Using the Sky temperature as an ally

PLACING A BPF WITH 0.18dB IL AHEAD OF THE DRILNA (0.38dB NF) RESULTS IN A TOTAL OF 0.56 dB NOISE FIGURE FOR THE FRONT-END

BECOUSE THE DRILNA HAS A EXCEPTIONAL IRL (-50dB) AND LOW NF AND HIGH GAIN THE GORAN's BPF FIT COMFORTABLE AND DELIVER ALL HIS SHARP CHARACTERISTICS; CONVERTING A BROADBAND AMPLIFIER IN A EXTREAMLY NARROW BAND PREAMPLIFIER WITH +36dBm OIP3 CAPABLE TO FIGHT AGAINST IM3 PRODUCTS ORIGINATED BY OUTBAND SIGNALS

Performance calculations

How does the NF increased from 0.38dB to 0.56dB affect the signal-to-noise ratio (s/n), and what role does sky temperature play?

Effect of Sky Temperature at 144 MHz:

Case A - No filter (0.38dB NF DRILNA)

$$T_{sys,A} = T_{sky} + 26.6$$

Case B - with filter (0.56dB NF BPF + DRILNA)

$$T_{sys,B} = T_{sky} + 40.0$$

Performance calculations

SNR degradation:

Is calulated by:

$$\Delta SNR_{dB} = 10 \log_{10} \left(\frac{T_{sys,B}}{T_{sys,A}} \right)$$

Performance calculations

Example 1 — Cold sky (200 K)

$$T_{sys,A} = 200 + 26.6 = 226.6 \text{ K}$$

$$T_{sys,B} = 200 + 40.0 = 240.0 \text{ K}$$

$$\Delta SNR = 10 \log_{10}(240/226.6)$$

$$\Delta SNR = 10 \log_{10}(1.059)$$

$$\boxed{\Delta SNR \approx 0.25 \text{ dB}}$$

Performance calculations

Example 2 — Typical sky (300 K)

$$T_{sys,A} = 326.6\ \mathrm{K}$$

$$T_{sys,B} = 340.0\ \mathrm{K}$$

$$\Delta SNR = 10 \log_{10}(340/326.6)$$

$$\boxed{\Delta SNR \approx 0.17\ \mathrm{dB}}$$

Performance calculations

Example 3 — Galactic plane (500 K)

$$T_{sys,A} = 526.6\ \mathrm{K}$$

$$T_{sys,B} = 540.0\ \mathrm{K}$$

$$\Delta SNR = 10\log_{10}(540/526.6)$$

$$\downarrow$$

$$\boxed{\Delta SNR \approx 0.11\ \mathrm{dB}}$$

Performance calculations

PLACING A BPF AHEAD THE PREAMPLIFIER GIVE YOU A VARIATION OF THE S/N IN A MEDIA OF ONLY 0.2dB DEPENDING WHERE YOUR ANTENNA IS POINTING THE SKY.

THIS IS A WINING TRADE PRACTICE WHERE A SMALL INCREMENT IN THE NF GIVE YOU A MUCH QUIET RECEIVER, ALLOWING TO RECOVER THE BAND FUNCTIONALITY DUE THE ABSENCE OF BROADBAND RESPONSE AND HIGH OIP3 LEVEL IN THE PREAMPLIFIER

Performance calculations

FINALLY:

At 144 MHz, the sky temperature is already on the order of a few hundred kelvin in many directions. Therefore, reducing receiver noise figure from 0.56 dB to 0.38 dB improves total system temperature only slightly.

By contrast, adding a 0.18 dB low-loss sharp BPF ahead of a well-matched, high-linearity preamp dramatically improves dynamic range and suppresses IM3-driven noise-floor lift, SOMETHING VERY CRITICAL TO EME, SPECIALLY FOR DIGITAL MODES

The true system trade is therefore not “0.38 dB versus 0.56 dB NF,” but rather “a theoretically quieter receiver” versus “a practically cleaner and more usable EME band.”

Performance calculations

Don’t be afraid to place a BPF IN FRONT of your preamp
But ensure your preamp has at least 20dB IRL otherwise
will not work properly

STOP THE NF CULT

Questions?