Low Noise Factory

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Wiring and biasing of LNF's cryogenic LNAs

Introduction

When procuring cryogenic LNAs from LNF, our customers have the option to buy accessories to help with the proper wiring and biasing of them. Since a cryogenic LNA is located inside the end-user's cryo cooler, LNF is unable to provide a standard solution for the wiring. Generally speaking, cryo coolers have different hermetic feedthroughs and the length of the wires inside and outside them differ in length. The allowed heat load from the wiring varies from case to case. LNF offers cables and accessories to make this wiring as easy as possible.

Accessories offered

All LNF's cryogenic LNAs require one gate voltage (V_{gs}) and one drain voltage (V_{ds}). Note that the optimum bias might vary slightly from unit to unit. Each LNA comes with test data of the actual unit at 4 K in a test report. The datasheet can be downloaded by scanning the QR code on the LNA package. The transistors inside the LNA are Field Effect Transistors (FET). V_{gs} is used to set and control the drain current, I_{ds}. An FET is a voltage controlled current source thus our LNAs have similar behavior. Since standard electronics does not work at cryogenic temperatures, we cannot integrate biasing management electronics inside cryogenic LNAs. We also aim to minimize the heat dissipated inside the LNA. There are ways to eliminate V_{gs} inside the LNA, but not without sacrifice in performance and repeatability.

LNF offers a low noise linear power supply, LNF-PBA, that converts mains voltage (100-230 VAC) to +/-12 VDC. Switch mode converters are cheap, small and efficient, but in many low noise applications they are unsuitable.

LNF offers a power supply which manages V_{ds} and V_{gs}. It is called LNF-PS3b. This supply is driven by +/-12 VDC from the PBA. The PS3b has a feedback loop that continuously adjusts V_{gs} to maintain a constant $I_{ds.}$ The user sets V_{ds} and I_{ds} on the front panel and the power supply automatically finds the correct V_{gs} to give the set I_{ds}. This combination of PBA and PS3b is the safest way to bias our

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cryogenic LNAs and ensures the best long- and short-term stability. The PBA can power 8 PS3b simultaneously.

Two cables are provided with the PS3b. LNF-CAB_PBA_PS3b is used between the PBA and PS3b to supply PS3b with +/-12 V. LNF-CAB_PS3b_LNA is used to connect the LNA to the PS3b. The LNA end of this cable is left without a connector. This end is typically soldered to a connector compatible with the vacuum feedthrough.

All LNF's cryogenic LNAs have a 9-pin nano-d connector to provide the DC power. This is a very small connector which is not offered with solder cups. LNF offers, as an accessory, a mating nano-d connector for our LNAs which is prewired with 46cm long 30 AWG copper wires. It is called LNF-NANO9M. It is not provided with the LNA and must be purchased separately.

Doing the wiring

Typically, an LNF cryogenic LNA is purchased together with the PBA, PS3b and a NANO9M cable. The PBA can supply eight PS3bs simultaneously. The PS3b can bias one LNA. The typical content of a shipment for one LNA is shown in Figure 1. A block diagram how to connect the delivered items is shown in Figure 2. The PBA is powered by 100-230 VAC. The power plug must have a ground prong. The PBA is connected to the PS3b with the LNF-CAB_PS3b_LNA*. The LNF-CAB_PBA_PS3b is used to connect the PS3b to the cryo cooler's hermetic electrical feedthrough. A suitable plug must be soldered to the blank end to fit the hermetic connector on your cooler. It is recommended the shield is left unconnected close to the hermetic connector. Inside the cryo cooler, the LNF-NANO9M is soldered to the vacuum side of the electrical feedthrough in one end and plugged into the LNA in the other end**.

*Please refer to the PBA manual how to operate the power supplies in floating mode, i.e. Earth not being connected to ground.

** Please refer to your LNA's datasheet for pinout of the NANO9M connector. Splicing the NANO9M to your internal cryogenic wiring might be necessary dependent on your needs.

Dealing with high resistance wires in the cooler

To reduce thermal losses, some cryo coolers are equipped high electrical resistance wires. According to Wiedemann-Franz law, the thermal conductivity in a wire is proportional to the electrical

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conductivity. The purpose of having high electrical resistance wires is to reduce the heat load from the wiring. In our opinion this is often overdone. Since LNF LNAs draw several mA of current, this resistance can cause a significant voltage drop in the drain and ground wires, which can lead to the LNA being biased at too low V_d. We recommend reducing the drain and ground wire resistance to a few ohms or less. The actual V_d over the LNA should be kept within ±50mV from the stated V_d in the datasheet. If the wire resistance and I_d are high enough to exceed this number, there are two ways to combat this problem.

1. Measure the actual wire resistance and compensate for that by adjusting V_d on PS3b.
2. Use the V_{dsense} function of the PS3b while setting V_d

In most cases, it is not recommended to have more than 0.5V total voltage drop in the wiring. For the case when not using the V_{dsense} function on the PS3b, please consider that in non-floating mode, the ground return currents can take a different path than through the intended ground wire and the resistance might be lower than expected. Please refer to the PS3b manual how to use the V_{dsense} function.

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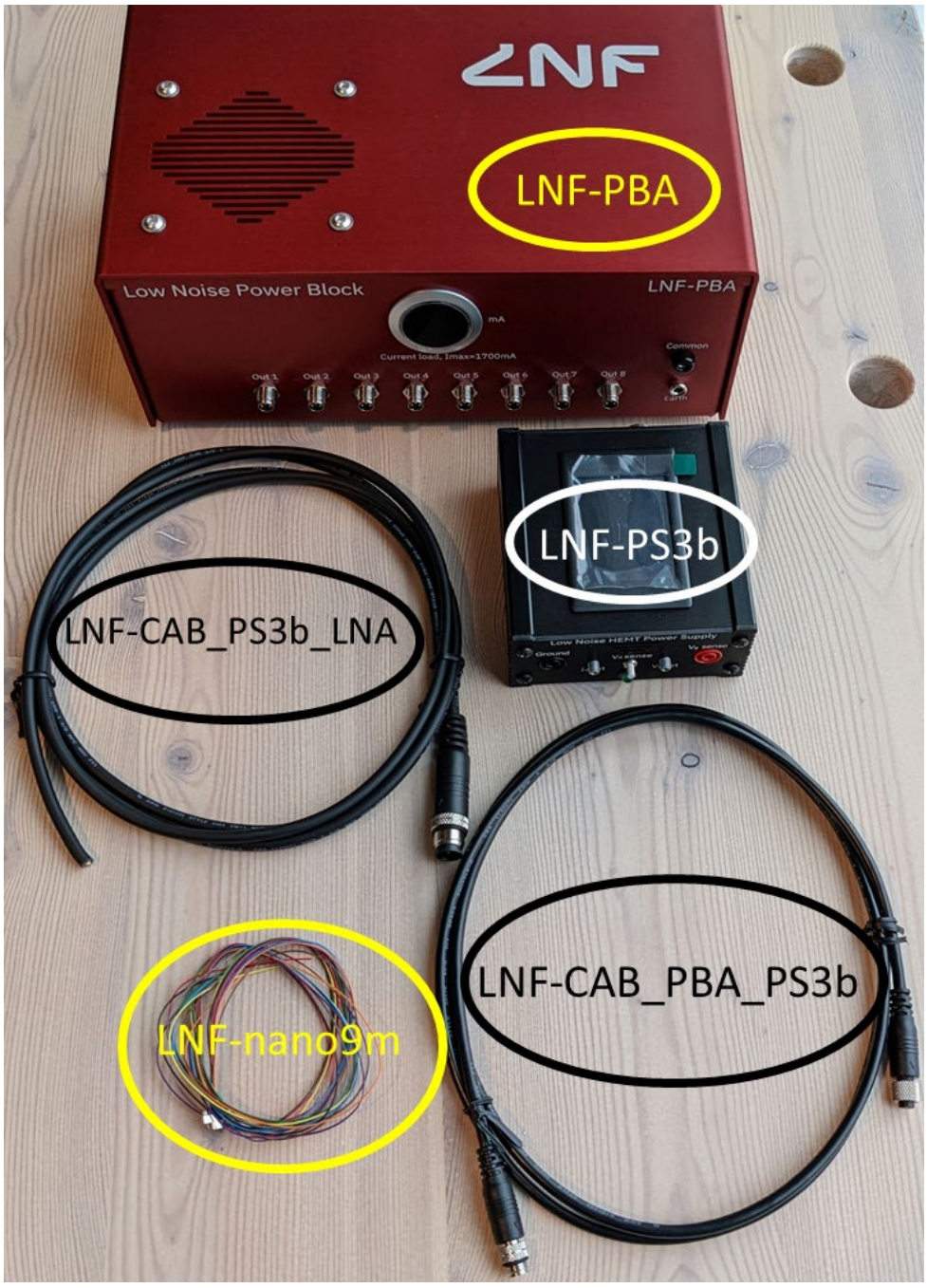

Figure 1. Typical content of a shipment

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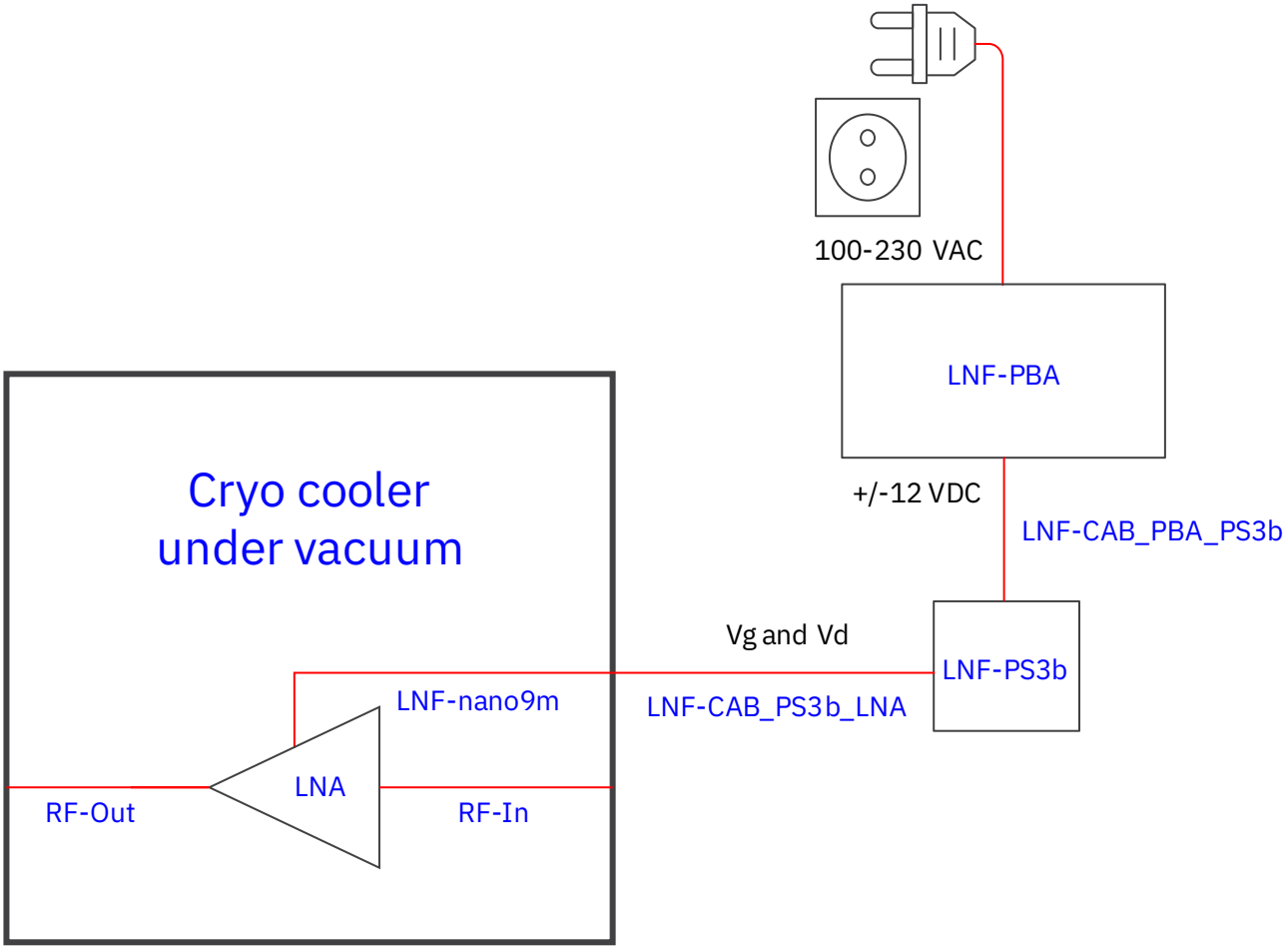

Figure 2. Schematic how to connect the provided items