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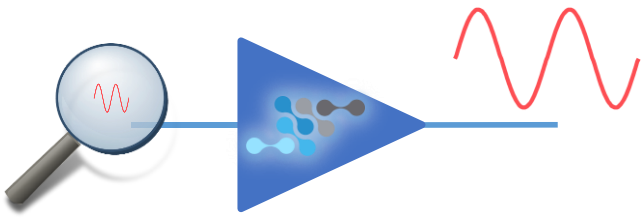
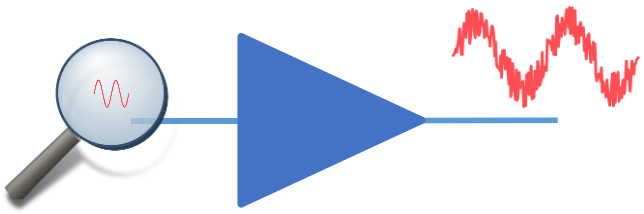
INTRODUCTION:

Low noise amplifiers (LNA) are devices capable of amplifying extremely weak signals and provide voltage levels suitable for analog to digital conversion or further analog processing. They are employed in applications involving low amplitude sources like many types of transducers and antennae. When dealing with weak sources, the performance of the measurement system is dominated by the gain and noise introduced by the first stage. Thus, the selection of a proper LNA is critical for the good operation of the experimental setup. This note provides a brief introduction to LNAs in order to help the user to understand their main parameters and choose an appropriate device.



Low noise amplifier



Standard amplifier

Behavior of a noisy amplifier:

Consider a real-life amplifier with a gain G. The input of such amplifier is defined by the desired signal S_i and an unavoidable input noise N_i. At the output, both signals will be amplified with a factor G. However, an additional noise N_{ampl} is introduced because of the

noise generated by the electronic components of the device. Good LNAs should provide a high gain along with a low internal noise N_{ampl} in order to accurately amplify a low-level signal.

Specifications of a LNA:

LNAs have the same specifications as ordinary amplifiers. However, they are intended to provide very high gains and add little noise to the input signal, so the user should focus on the parameters concerning the noise response of the amplifier:

- **Noise factor and noise figure:**

The noise factor (F) compares the noise output of an amplifier with that obtained with an ideal noiseless device. The noise factor of any amplifier is always higher than 1 because electronic components unavoidably introduce noise. A related parameter is the noise figure (NF), which is the noise factor converted to decibel notation, i.e., $NF = 10 \cdot log_{10}(F)$. A good quality LNA should present a NF close to 0dB (or F close to 1), which is the limit of a noiseless amplifier. The noise factor is dependent on the impedance of the source that provides the input signal. Because of this, its value is provided for a specific value of source impedance.

- **Noise spectral density:**

The noise spectral density (NSD) refers to the distribution of intrinsic noise power of the amplifier over its bandwidth. It corresponds to N_{ampl} in the figure above, although it is usually expressed as the equivalent input noise (N_{ampl}/G) for a better comparison with the noise of the input signal. The NSD is provided in $nV/\sqrt{Hz}$ for specific frequencies or averaged over the whole bandwidth of the amplifier. In some cases, the curves of the NSD as a function of the frequency are also provided. Roughly speaking, good-quality LNAs present spectral densities below 10n$V/\sqrt{Hz}$.

OTHER PARAMETERS:

Additional parameters that the user should check when assessing a LNA are:

- Gain: The gain required for a specific application will depend on the levels of the signals intended to amplify. Values of gain ranging from 10^2 to 10^4 (40dB to 80dB) are not uncommon in low-noise measurements where signals on the order of µV are converted to tens or hundreds of mV. A rough estimation of the required gain is recommended since too low gains result in a poor amplification while too high gains lead to amplifier saturation.

- Bandwidth: The bandwidth of the amplifier should cover the range of frequencies of the signal intended to measure, including DC operation if required.

- Offset: This parameter only affects to amplifiers with DC operation. It consists of a spurious DC level that appears at the output of the amplifier due to the intrinsic limitations of any modern semiconductor device.

- Input impedance: The input impedance of the amplifier has a significant influence on the noise added to the output signal. The higher the impedance, the higher the noise levels. However, a low input impedance could lead to poor measured levels when the low signal source has a high impedance, like in the case of piezoelectric transducers. In these situations, a higher input impedance may be necessary.

Please, contact us at support@ciprian.com if you have questions about the use of low noise amplifiers in your specific application.

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