Gain and noise analysis of HEMT amplifiers from room temperature to superfluid He.

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- We are developing a new microwave parametric transducer for massive gravity wave antennas, like bars and spheres, based on the high sensitivity of a superconducting RF cavity to the change of the appropriate geometrical dimension.
- To fully exploit the transducer sensitivity, a very low noise amplifier, at the operating frequency of few GHz, is required.
- We describe the experimental set-up and the test procedure that has been used to measure the noise temperature and the gain of the LNA at several temperatures, from 300 K to 1.5 K.
- The influence of an imperfect impedance matching with the temperature change is investigated. A commercial GaAs LNA has been used to measure the noise temperature and the gain of a superconducting RF cavity at the operating frequency of few GHz, as required. To fully exploit the transducer sensitivity, a very low noise amplifier, at the operating frequency of few GHz, is required.

The most critical RF components in a typical detection scheme for a massive gravity wave antennas, like bars and spheres, are the cryogenic VCO in a sealed into the amplifier box, which is cooled through the RF cable that connects the mixer to the He vessel. We use an heater to provide different temperature of the noise source.

Both are needed to work at low temperature.

The mixer contribution to the performance is comparable to the amplifier one. This mixer, or at least its use in this configuration, is not necessary, and we are looking for a more compact, low noise mixer.

The amplifier temperature is likewise precisely controlled with calibrated sensor.

The noise temperature of a HEMT (Km=3.36 K @ 1.96 GHz, which amounts to 15 K @ 5 GHz, @ 300 K)

\[
T_n = 4k_B R T \tau G (T_{eff} + P)
\]

\[ P \sim 20 \times 10^{-12} \text{mW} \]

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Alternatively, a more complex configuration such as the use of 2 cascade amplifiers and a mixer can be tested.

**Conclusion**

- The RF amplifier is one of the most critical device for designing a high frequency parametric transducer.
- We have shown that a careful implementation of commercially available components can lead to a noise temperature as low as 3.5 K, which corresponds to ~15 h at 5 GHz.
- Since the parametric conversion does not introduce additional noise in the system, the signal detection at very high frequency has the advantage of a readily available critical components, which works near their quantum limit.
- The implementation of other critical components such as mixers, circulators, attenuators, phase shifters and low-noise cables are under scrutiny.