High input impedance LNA with passive negative feedback for high field imaging

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Introduction

In parallel imaging, one method to decouple the elements of a multi-element array is to use a high (or low) input impedance preamplifier. In order to obtain high input impedance and low noise figure, preamplifiers use conventional GaAs-FET technology as first stage of the preamplifier. However, GaAs FET show a strong dependence of the gain and input impedance as function of intensity and orientation of magnetic field [1]. In this paper, we describe a new high impedance preamplifier, which does not use FET technology, but it is able to guarantee high input impedance and low noise figure for MR applications.

Methods and Materials

The amplifier was designed at 3T and it is required to have a ratio between input impedance Zin and optimal impedance for noise matching Zopt higher than 20. Moreover the amplifier was designed with special attention on manufacturability, stability and magnetic field dependence of the used components. We employed the use of Bipolar or MOSFET technology in at least the first stage of the preamplifier in order to keep the RF parameters (e.g. gain, input impedance, noise behaviour, etc.) independent on magnetic field strength and orientation [2]. In order to obtain a good compromise between performance and manufacturability, this amplifier makes use of *Passive Negative Feedback Amplifier Topology,* as shown in Figure 1.

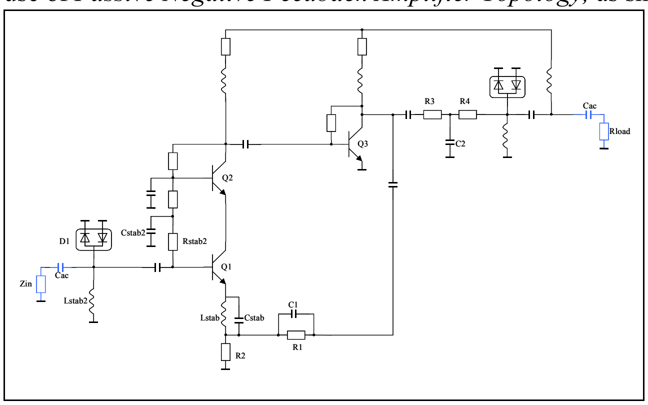

Figure 1. Basic schematic of the design

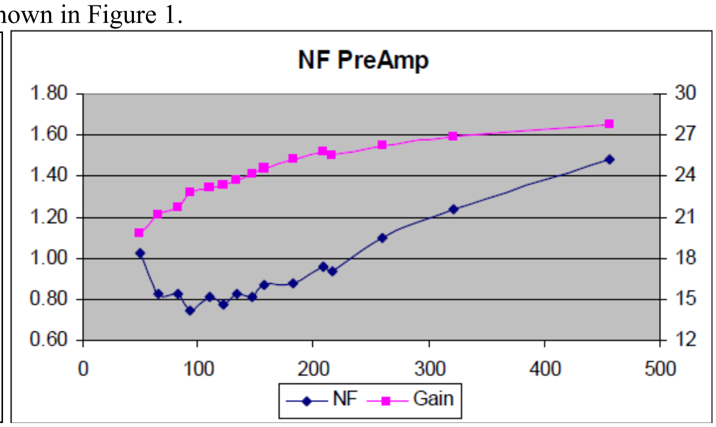

Figure2. Gain and NF measurements of preamplifier as a function of impedance

The Passive Negative Feedback corrects many of the tolerances of the transistors (Q1, Q2 and Q3). This mechanism allows better control of critical parameters like gain, impedances and settling time but also allows more freedom in choosing the transistor (type). Therefore no adjustments are required in order to improve manufacturability and the preamplifier results less sensitive for voltage and temperature variation. Moreover, the stability of the preamplifier has been improved by adding 1) an out-of-band termination at the input and at the output, 2) a wideband (non-resonant) passive output matching and 3) components in the Passive Negative Feedback and in the emitter of Q1 in order to lower the cut-off frequency of the preamplifier.
Finally the input and output are protected with an RF clamp, ensuring proper operation even after excessive RF voltages that can occur during the transmit phase.

Results and conclusions

Measurements at 128MHz reported in Figure 2 show the gain and the noise figure (NF) of the preamplifier and the matching circuit for a typical coil load as a function of a (real) source impedance. The optimum NF-impedance is around 120Ω and with a small reactive part of –20j ohms. The NF measurement inaccuracies (0.2dB) are affected by the mismatch between the Noise Source, Noise Matching and the preamplifier whilst the contribution of the output mismatch of the PreAmp is minor (Friis Law). S-parameters were measured on a range of 3GHz, also validating the in-band stability. Wideband stability has been verified by using wideband (22GHz) Spectrum Analyser for different source/load situations and end applications. Those results are in agreement with the preamplifier simulations which include non-linear models and parasitic behavior of components and PCB.

References

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