Ultra low noise preamplifier for transmit/receive coils: Upgrading MR systems without further modifications of the hardware

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Introduction:

Optimizing the SNR of NMR applications can be achieved by using low noise preamplifiers. To avoid signal losses and external perturbations it is advantageous to connect preamplifiers as close to the coils as possible. For transmit/receive coils this implies in general additional wiring for transmission and tuning/matching.

In this work we propose a low noise preamplifier with an integrated transmit bypass. No additional wiring is needed for transmitting and tuning/matching. It is noise matched and therefore can advantageously be attached directly to the coil [1]. Furthermore, the preamplifier is adjustable over a wide frequency range. Due to its small dimensions and single wire connection it can be integrated in many existing MR systems without the need of further modifications.

Methods and materials:

The proposed preamplifier concept consists of three parts: the transmission bypass, the low noise preamplifier and the DC power supply. The transmission bypass is realized with passive diode switches which bridge the amplifier during transmission. This enables to transmit and receive with only one wire. The DC power supply is fed to the amplifier over the same wire and separated from the signal by a RF choke. This concept allows the use of a single coaxial cable connection to the MRI system (Fig. 1). The preamplifier is based on a low noise GaAs FET. The input network is an optimized noise matched high-pass LC circuit which behaves similar to a λ/4-line. Combined with crossed diodes it protects the input from high powers. The output is matched to 50 Ω. It is protected from high powers by using a discrete λ/4-line together with crossed diodes. The used double sided circuit board has outer dimensions of 11.2 mm x 26.7 mm (Fig. 2). Exemplarily, 20.0 MHz and 42.6 MHz versions were built.

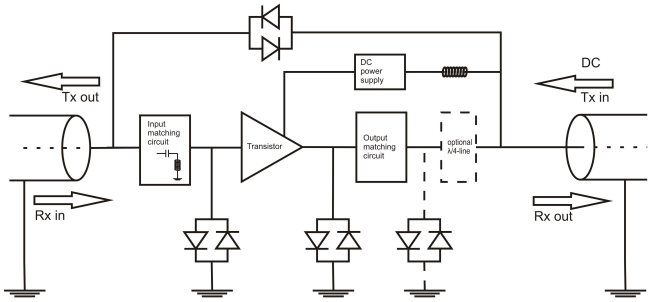

Fig. 1: Block diagram of the preamplifier

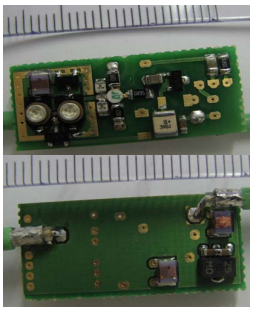

Fig. 2: Image of both sides of the 42.6 MHz Preamplifier

Results:

Using this preamplifier concept, tuning and matching of transmit/receive coils was possible. The preamplifier also provides an excellent noise figure. For the 42.6 MHz version, a noise figure of 1.0 dB with an amplification of 21.5 dB was achieved. The 20.0 MHz version had a noise figure of 1.7 dB with a gain of 20.5 dB. The design is portable to different frequencies with minor changes. The device is completely non-magnet and can be placed close to the coil. Signal can be received 4μs after transmission due to the optimized short dead time of the passive switches.

Conclusion:

The presented preamplifier concept allows tuning/matching of transmit/receive coils, has an excellent noise figure. Due to its single wire connection it fits in most MR probes. Having all these properties, our design has the potential to improve the SNR of many existing MR scanners.

[1] Reykowski *et al.* Magn. Res. Med. 33:848-852, 1995