Low Noise Preamplifier with integrated Cable Trap

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Introduction:

Cable traps in MR generally have several functions. One is to suppress sheath waves during transmit which is a prerequisite for patient safety. Another is to balance the loop antenna during receive which avoids uncontrollable feedback and thus prevents the preamp section from unwanted oscillations. With increasing MR-frequencies involved with higher magnetic field strengths the leakage current through stray capacitances linearly increases with frequency. Thus, more and/or more effective cable traps are required in high field MR-systems.

Methods and Results:

In the proposed design, the cable trap is realized as a bifilar coil and integrated in a cascode preamp circuit between the first and second gain stage [1]. Thus, the relatively low gain prior to the trap minimizes its feedback to the loop antenna. On the other hand, the gain is high enough to avoid noticeable noise figure degradation. A worse noise figure would result if the trap is located prior to the first gain stage. After preamplification the differential mode wave carrying the MR-signal can pass with little attenuation to the second gain stage (see basic arrangement in fig. 1). The over all noise figure of the preamp can be kept below 0.5 dB.

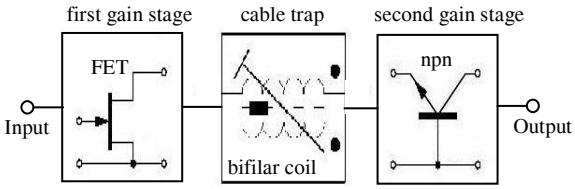

Fig. 1: Location of the cable trap in a cascode type preamp

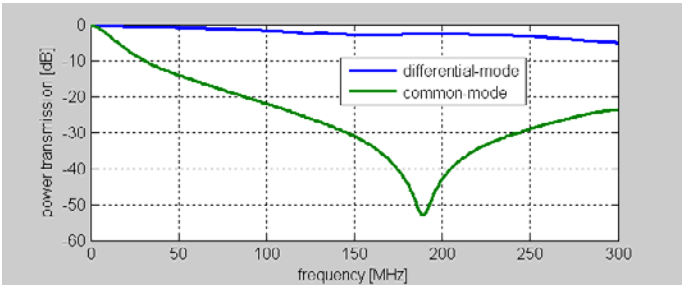

Fig. 2: Common- and differential mode frequency response of the bifilar coil designed for 180 MHz center frequency in free space

The electrical length of the two-wire line formed by two adjacent coiled-up wires is λ/2 which represents an impedance auto-transformation [2]. Thus, the introduction of this trap between the two cascode gain stages barely influences the original amplifier's performance. Fig. 2 displays the common- and differential mode frequency response of a bifilar coil cable trap designed for 180 MHz center frequency in free space. A common mode suppression of about 50 dB was achieved. Due to capacitive loading effects on both sides of the bifilar coil the center frequency will shift down after mounting it on a printed circuit board.

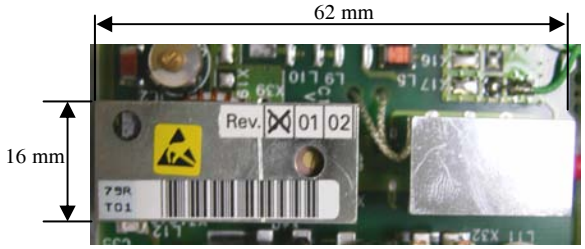

Fig. 3a: Conventional design with screened preamplifier (left) and cable trap (right)

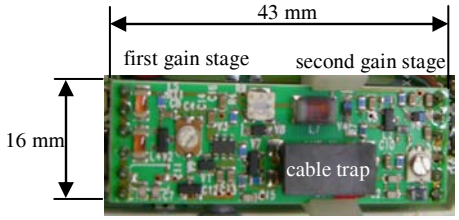

Fig. 3b: New design with cable trap integrated between the first two amplifier stages

Fig. 3 shows a comparison of the conventional (3a) and new (3b) design. Besides a significant space saving, the unwanted feedback from the amplifier output to the loop antenna connected to the input is also reduced. Thus, the amplifier-cable-trap-arrangement is well suited for multi channel loop arrays.

The first matrix coils making use of the new low noise amplifier with integrated cable trap already have been designed and successfully tested in 3T-MR-systems.

References:

[1] Oppelt R., Vester M.: "Antennenverstärker für eine Magnetresonanzantenne sowie Magnetresonanzantenne mit einem Antennenverstärker", German patent# DE 10 2004 026 713, see also: „Antenna Amplifier, in Particular for a Magnetic Resonance Antenna", Pub. No. US2005/0270031

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