Modular Preamplifier Design and Application to Animal Imaging at 7 and 11.7T

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Introduction There continues to be a push to higher magnetic fields for both animal and human imaging. There are a large number of 7T animal and human systems, a number of horizontal bore 11.7T MRI systems for animal imaging, and the first 16-17T systems are coming on line. Due to the specific challenges of these high fields and the need for high performance receivers, we are currently developing building blocks for coil development for these high field systems. Here we report the development of low-impedance, low noise preamplifiers and applications of this technology to a high-field phased array for imaging of small animals at 500 MHz.

Methods Low-noise preamplifiers were designed for both 7T and 11.7T using the USAI architecture [2] as a starting point. The circuit, shown in Fig. 1 differs from the USAI design in that it uses GaAs FET's (Agilent/Avago ATF 34143) for both stages and it does not use diodes for biasing of the second stage. The preamplifier was designed to be modular by assembling it on a 12mm x 54mm PCB equipped with miniature MMBX coaxial "snap-on" connectors. These connectors were used to mate the preamplifier to a supporting 'mother board' designed for each coil array. Preamplifiers were assembled using the same PCB for both 300 and 500 MHz; the design and performance parameters are summarized in Table 1.

Coil arrays using 300 MHz preamplifiers have been used with 4-element arrays and tested on a Bruker 7T/30 system for small animals [3]. A similar 4-element array using 1 cm diameter surface coils in the standard phased array configuration [4] was assembled and tested on a Bruker 11.7T animal system. Shown in Fig. 2, the array uses a λ/2 line between the preamplifier and the coil with the preamplifier isolated from the coil using a planar cable balun.

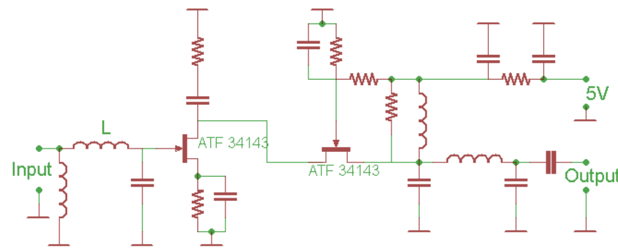

Figure 1. Preamplifier schematic.

Table 1 Preamplifier design and performance

Freq, MHz	Ibias	L	Input R	Gain, dB	NF, dB	IP3
300 (7T)	35 mA	33 nH	1.4 Ohms	27	0.5	22 dBm
500 (11.7T)	35 mA	16 nH	2 Ohms	25	0.6	-

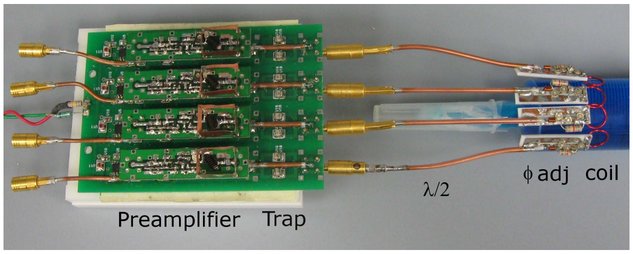

Figure 2. 4-Ch Phased array coil**.**

Results The 4-element phased array was situated around a 30 mm cylindrical phantom filled with normal saline and copper sulphate. In this particular arrangement four 1-cm diameter coil elements were used ($Q_U/Q_L = 2.0$), with the top two coils being overlapped and the outer two being spaced with a 2 mm gap. Spin-echo images were acquired using a .5 mm slice, 32 mm FOV, 256x256 points, TE = 12 msec, TR = 0.5 sec. Images from each element and the combined image are shown in Fig. 3. Preamplifier decoupling gave better than -15 db isolation.

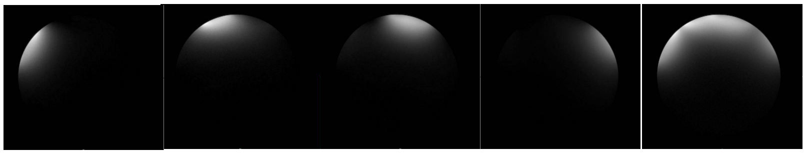

Figure 3. (a-d) elements 1-4, and (e) combined image from all elements. Compared with a 20-mm diameter surface coil typically used for rat brain imaging, a 2.0 SNR increase is observed at the top of the image, and 1.5 times at the location of the base of the rat brain.

Conclusions The basic cascade architecture was found to be stable and provide high output-to-input isolation (> 40dB). Performance of these preamps at high frequency demonstrates that the two-FET as opposed to the FET-bipolar design also works well. The power supply has been reduced from a typical 10 Volts to 5 Volts without large reduction in dynamic range. These preamps should serve well as gain blocks for 7T and 11.7T human applications.

References 1. T. Lanz, et al., Proc. Intl. Soc. Mag. Reson. Med. 14, 2589 (2006). 2. M. de Rooij, et al., Proc. Intl. Soc. Mag. Reson. Med. 15, 1006 (2007). 3. G. Nascimento, et al., Proc. Intl. Soc. Mag. Reson. Med. 16, 1099 (2007). 4. P.B Roemer, et al., Magn. Reson. Med. 16, 192 (1990).