A receive chain add-on for implementation of a 32-channel integrated Tx/Rx body coil and use of local receive arrays at 7 Tesla

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Target Audience: RF system developers at ultra-high field.

Purpose:

Local Tx/Rx arrays for body imaging at ultra-high field are often bulky and consume much of the space inside the small diameter bore of the magnet (1-3). This limits the patient size to those with a fairly slender body physique. To allow patients with a larger body physique and a more clinic-like workflow, an integrated Tx/Rx body coil situated between the gradient coil and the lining of the scanner bore might be an option. In this work, a receive chain add-on that allows the use of an integrated 32-channel Tx/Rx body coil together with local 32-channel receive arrays was developed.

Materials and Methods:

Figure 1 A shows a schematic of portions of the receive chain of a Siemens 7 T system equipped with an 8-channel parallel transmit system. For implementation of an integrated 32-channel Tx/Rx body array, several components have to be added. For supply of power to the pre-amps of the body coil and signal amplification, a 32-channel low-noise amplifier with bias tee was designed and implemented. Furthermore, two 32-channel switches were implemented. The first one (SRS) is used to choose between the signals coming from a local coil or the body coil, the second switch (SSS) is used to switch between the coil signals and the signals coming from the RF power amplifiers (RFPAs) for power supervision.

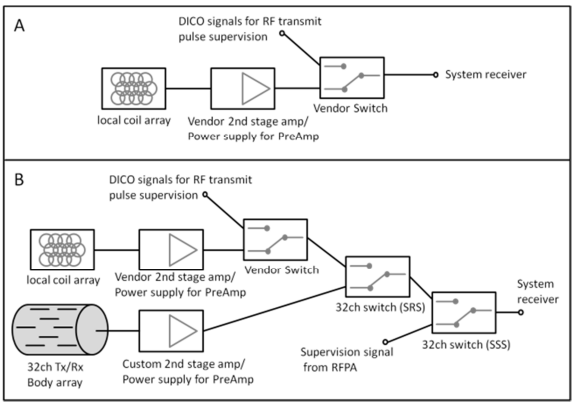

Figure 1: A) Setup before implementing the add-on. B) Setup after implementation of the add-on.

Figure 2 shows a schematic for one channel of the 2nd-stage amplifier with bias tee. Centerpiece of the LNA is a MGA-62563 monolithic amplifier (Avago Technologies) with an output power at 1dB gain compression P1dB = 18 dBm and an output 3rd-order intercept point OIP3 = 34.8 dBm (at 300 MHz, taken from datasheet). The LNAs and bias tees are optimized for 297MHz and placed in two boxes with 16 channels each, with a common power supply of 3V and 10V in a third box. This power supply can be switched on and off remotely via an optical signal.

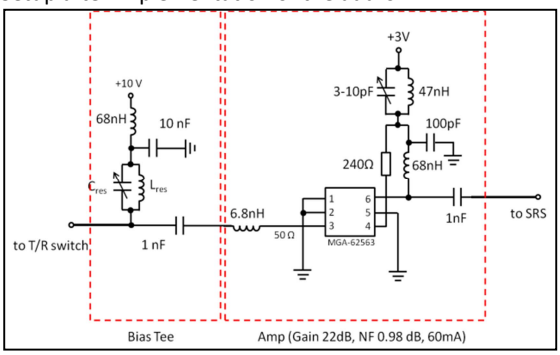

Figure 2: Schematic of one channel of the 2nd-stage amplifier with bias tee for power supply of pre-amp.

Figure 3 shows a schematic for a single channel of the 32-channel switches. It consists of 3 MASWSS0115 GaAs SPDT switches that are controlled via two voltages V1 and V2. They are connected in such a way that the input that is not connected to the output is terminated with a 50 Ω resistor. Input selection is done via an optical signal. Since these switches are vital for safety monitoring, two optical lines with one transmitter and receiver each are connected to each switch in case a transmitter or a cable is damaged.

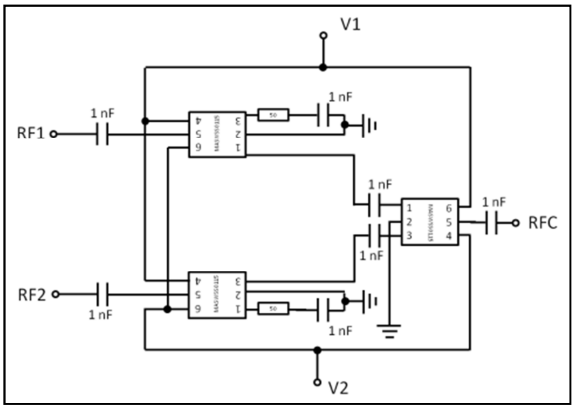

Figure 3: Schematic of one channel of a 32ch switch. By applying +5V to either of the inputs V1/2, the signal of either RF1 or RF2 is sent to RFC, while the other is terminated with 50 Ohms.

Results & Discussion:

Workbench measurements show that the amplifier together with the bias tee has a gain of 22 dB and a noise figure of 0.98 dB. The switching times (T_{on} and T_{off}) were below 2 µs. The isolation between all channels is better than -60 dB. When used as a substitute for the vendor amplifiers, a 10% reduction in signal amplitude can be noted due to a slightly lower gain. The SNR shows no difference.

Within a frequency range of 50 MHz to 325 MHz, the 32-channel switches have an insertion loss of less than -0.6 dB and the isolation between the two inputs is better than -60 dB, indicating that the switches are also suitable for X-nuclei if local X-nuclei arrays are used. The isolation between all channels within a 32-channel box is also below -60 dB.

All components were tested close to the magnet within a static magnetic field of 1 to 1.5 T.

Conclusion:

A receive chain add-on that allows implementation of an integrated 32-channel Tx/Rx body coil was successfully developed. The add-on maintains normal system operation including acquisition of X-nuclei. All components were successfully tested close to the magnet in a static field up to 1.5 T.

References: Metzger et al. MRM 59:396-409 (2008), 2. Orzada et al. Proc. Intl. Soc. MRM 2009 #2999, 3. Raaijmakers et al, MRM 66:1488-1497 (2001).

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