An 8 channel TX-RX head array for improved SNR at 3T

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Introduction

Phased arrays have been used to combine the good local SNR of surface coils with the large FOV of volume coils [1] and to accelerate image acquisition [2]. Römer et. al. showed how preamplifier decoupling can be utilized for additional decoupling to allow receive-only arrays [1] to be operated. Since then a large variety of receive-only arrays has been built and has shown to work effectively. Here the whole body coil is commonly used to excite the sample whereas the phased array receives the NMR signal. Sometimes it is necessary to implement an array that is used for both, transmission and reception. This may become useful for example if there is no integrated body coil or if there is simply not enough space to implement two separate coils. Localized TX-RX coils also reduce the power deposited in the sample and allow for accelerated TX technologies [3][4].

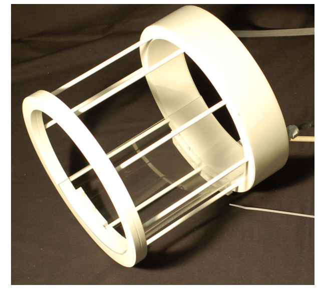

Figure 1: 8 Channel TX-RX head array for 3T

Methods

Multi-channel TX-RX arrays have been built with strip lines or gap arrays so far [5][6]. Such designs provide a high degree of intrinsic decoupling but also offer a relatively low efficiency which results in a reduced SNR. We have built an 8 channel TX-RX head array which uses the conventional design with rungs and lumped capacitors to tune the coil elements. This conventional design allows the coil to be very open. The decoupling of elements was achieved with an additional capacitive network as proposed by Jevtic et al. [7]. This network distributes some of the element's current to its next nearest elements to compensate their mutual magnetic flux. Figure 2 shows the block diagram of one coil channel. Each channel is composed of the single coil element, a TR-switch and a preamplifier in the RX-path. Wave traps are located between the coil element and TR switch. The TX pulse is fed to each element through an external 1-8 power splitter. Generally this architecture allows the coil to be used with 8 independent transmitters e.g. for TX-SENSE or TX-GRAPPA experiments Figure 1 shows the coil with its 8 rungs and the 2 end-rings. The array has a total length of 300mm, an inner and outer diameter of 265mm and 310mm and it incorporates an interface to a Siemens Allegra MR system with a bore of 350mm.

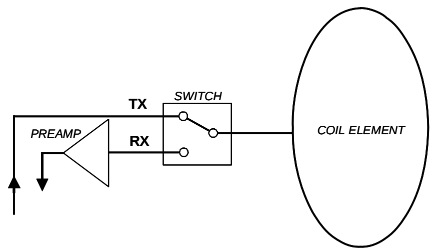

Figure 2: Block diagram of one single channel of the array

Results and Discussion

The unloaded Q-factor of a single element is Q_0 = 220 and reduces to Q_L = 90 when loaded with an average sized head. Element decoupling was measured as S_{12} when coupled to 50 Ω. Neighbouring coil elements are decoupled to approximately -13dB, next nearest neighbours couple with -20dB and following elements couple less than -24dB. The SNR was calculated pixel-wise from the signal amplitude and its temporal variation for a series of 160 gradient echo images obtained with the head array and the system's standard quadrature birdcage. Prior to the scan a 32 second long dummy scan was performed to avoid signal variation due to saturation. Figure 3 shows the SNR of a transverse line profile through a 160mm diameter cylindrical Siemens head phantom (5512608 k2205) for both coils. The birdcage's SNR shows a maximum at the centre due to dielectric resonances within the relatively large sample. The array provides an increased sensitivity towards the edge of the phantom. One might expect the SNR at the centre to be the same for both coils. Additional loss mechanisms from the electric field or the far-field may be the reason for the birdcage's slightly reduced SNR. The birdcage has also a larger inner diameter of 275mm which might also account for the SNR reduction. Figure 4 shows accelerated TSE-images (g=1, 2, 3, 4) acquired with the array on a Siemens Allegra system.

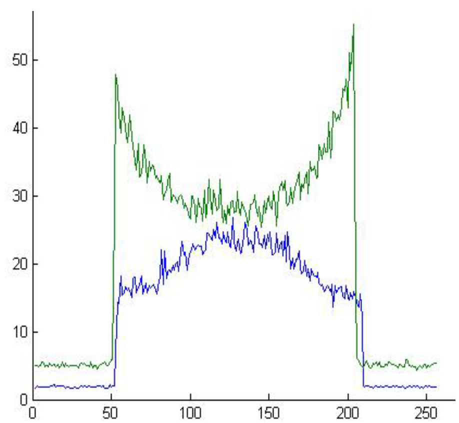

Figure 3: SNR comparison between 8 channel TX-RX head array (green) and standard Allegra quadrature birdcage (blue). Displayed SNR was measured from 160 GRE acquisitions with TE=2.2ms; TR=4.4ms, flip angle=12°, matrix: 256^2, slice thickness: 8mm. The channels of the head array were combined as SOS.

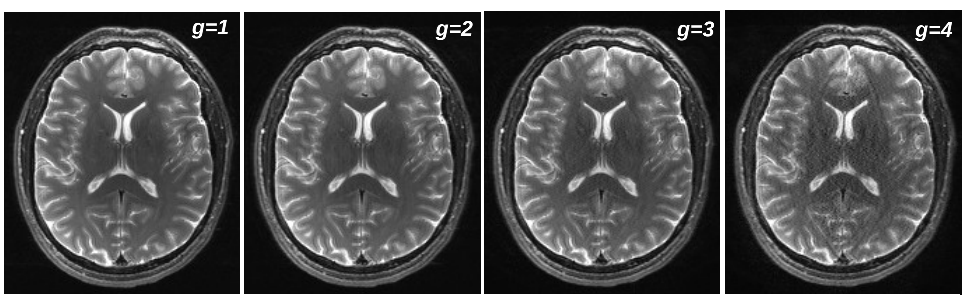

Figure 4: TSE images of a human head acquired with TX-RX head array with different acceleration factors (g); TE=84ms, TR=5.4s, 256x192 matrix, slice thickness=3mm, acquisition time=70s (g=1)

Conclusion

The decoupling mechanism provides sufficient isolation of the individual elements to allow operation in TX-RX mode. The coil's conventional design with lumped elements offers good SNR and provides the option to perform TX-SENSE [4] if supported by the MR system. It also allows an open and compact design of multi channel TX-RX arrays.

References

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