Parallel Transmit with a single Exciter and a Multi-Channel Controller

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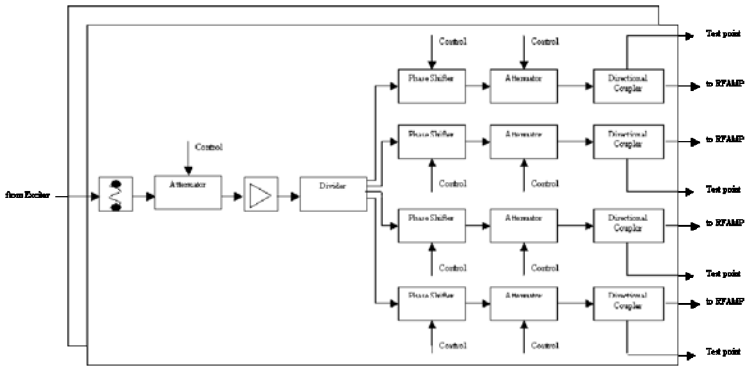
Introduction

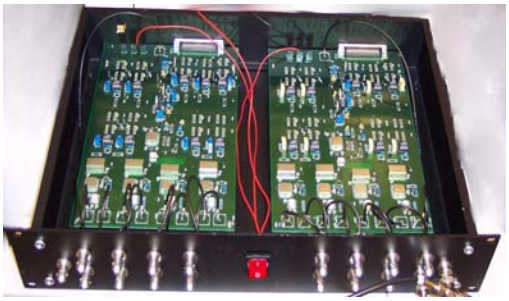
At high field (≥ 3 Tesla), increasing B1 field non-uniformity poses a major challenge, because of RF wave interference, un-symmetric loading and non-ideal transmit coil design. This has practical consequences for diagnostic imaging, as the circularly polarized B1 field becomes patient-dependent and may lead to loss of signal and/or contrast.

The use of multiple RF excitation coils, each connected to an exciter board with microsecond control over the individual waveforms has been proposed as a solution in the context of Transmit SENSE (1,2). This requires substantial changes to a clinical MR scanner, and addition of expensive hardware. Here we assess the potential of scalar amplitude and phase control in a simplified setup, using a single RF exciter in combination with a Multi-Channel Controller (MCC) to split and adjust the excitation waveform. The concept was tested using four transmit coils, arranged in a planar configuration to assess performance with very strong B1 variation.

Methods and Materials

The MCC is comprised of two identical subunits. Each of the subunits splits an incoming signal into four output channels. As shown in Fig. 1, the input from the Exciter first passes a preamplification stage in order to compensate for the insertion losses of the following components and provide a nominal power level between –3 – 0 dBm. Behind the preamplification stage the power is split up equally between the four output channels, which are routed to a set of four amplifiers. In each channel the signal power and phase are adjusted using voltage-controlled adjustable attenuators and phase shifters (Fig. 2).



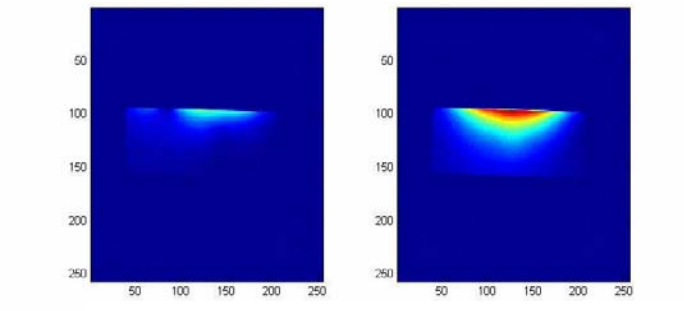


The MCC is driven by two Labview-controlled National Instruments Analog Output Cards in a peripheral PC, which is controlled by the MRI console using network communication protocol. Adjustments are possible with 16-bit precision over both a range of 0-200 degrees phase shift and 0-20dB attenuation. The MCC was calibrated before use in the MRI scanner system using an Agilent 4395A network analyzer. For each control voltage, the resulting output signals were stored in a look-up table.

For excitation, we used a four channel planar transmit array (Fig. 3). The array was strapped onto a standard GE body phantom, and placed in a 3T GE Signa Excite HD MR scanner. Images were acquired with a 3D-fast spoiled gradient echo sequence, without and with optimization of the individual control elements.

Results and Discussion

For the same RF power, a mean gain in SNR of 290% was found by properly adjusting the phase of the individual RF waveforms. Additionally, RF penetration and homogeneity were considerably improved (Fig. 4). These preliminary results show the potential of using a MCC for RF transmission to overcome inhomogeneous excitation profiles without the need for additional exciter hardware, pulse sequence modifications or at the cost of increased scan time.



References

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2. Katscher et al. ISMRM 13 (2005), 2256