8-Channel Eigenmode Tx-Array at 3T for Tx-SENSE

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Introduction

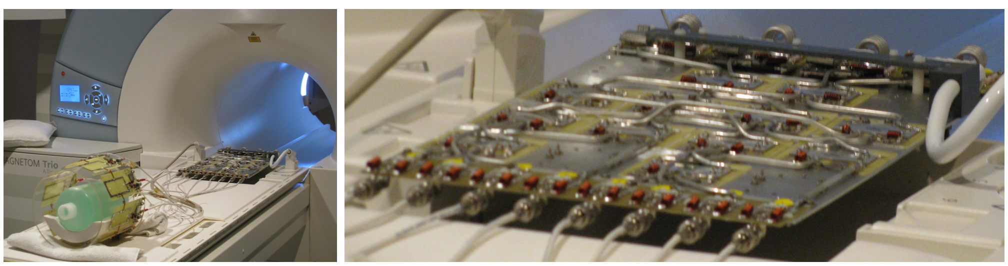
Tx-SENSE is used to reduce the pulse length of 2D and 3D spatially selective RF pulses. The design of array coils for Tx-SENSE applications is complimentary to the design of an array for Rx parallel MRI. Therefore, Tx-array elements that have B_1 field distributions that are completely orthogonal may allow the complimentary effect of data compression [1] but on the transmit side for Tx-SENSE applications, minimizing the number of transmit channels required to achieve a certain Tx-SENSE reduction factor. Here we report on an eigenmode [1,2] Tx-array solution that generates 8-channel orthogonal B_1 fields used in conjunction with an 8-channel transmitter MRI system for Tx-SENSE MRI.

Methods

A Siemens prototype 8-channel transmitter system on a Siemens 3T Trio-Tim MRI system was used with a Tx-array design (*Fig.1-left*) consisting of eight 4 x 10 cm elements evenly distributed azimuthally over a 20cm cylinder, inductively isolated with shared inductors, giving a resultant isolation of better than –17dB, when loaded with a 12cm diameter cylindrical saline phantom. The 8-to-8 eigenmode power splitter was constructed using 25 high power quadrature hybrids (Anaren 1J0280-3, .1-.6GHz) as building blocks with additional phase shifters to generate the required eigenmode basis set combinations, an alternative to utilizing a Butler matrix signal splitter method connected to a Degenerate Birdcage Coil [3]. The 8-channel array (123.2MHz) was constructed using 1.8Ω input impedance pre-amps, active T/R switches, and cable traps and balanced matching inputs to each element. Standard FLASH images were collected (TR/TE= 500ms/10ms) receiving independently with each loop array element.

Results

The goal is to drive an 8-channel Tx-array with eight sets of optimized voltage amplitudes and phases to produce eight orthogonal eigenmode fields [1,2]. Figure 2 shows the quadrature modes expected from simulations for the amplitude (B_1+) and phase distributions. Figure 3 shows the eight images collected (*top*) and the phase distributions (*bottom*) relative to the phase of the uniform CP mode, which is assumed to have uniform phase, using the 8-channel eigenmode Tx-array.



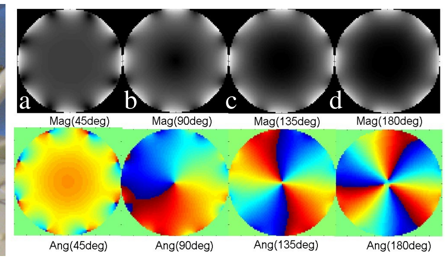


Fig. 1: Tx-array (left) with Eigenmode power splitter (middle); **Fig.2** (a-d) Simulated B_1+ eigenmodes (magnitude-top, phase-bottom) over the entire 20cm inner volume from driving with equal magnitude and successive phase of (a) 45°(Uniform), (b) 90°, (c) 135°, (d) 180° delivered to Tx-array.

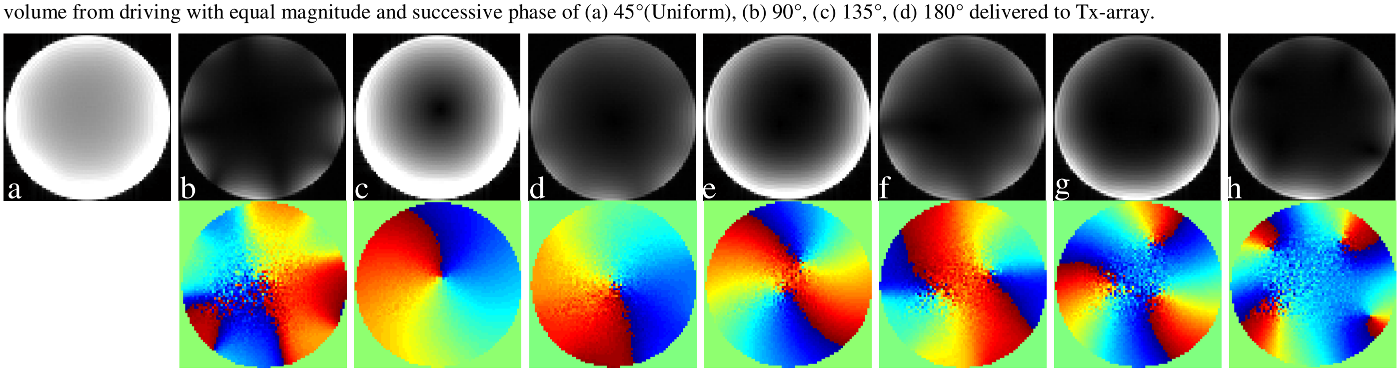


Fig.3: Images collected (top) and phase maps (bottom) from separately driving each eigenmode Tx-array field. (a) Uniform (+45°) Quadrature mode, (b) Uniform (-45°) Antiquad mode, (c) 1st order (90°) Quad mode, (d) 1st order (-90°) Antiquad mode, (e) 2nd order (+135°) Quad mode, (f) 2nd order (-135°) Antiquad mode, (g) 3rd order (180°) mode, (e) Endring (0°) mode

Discussion/Conclusions

Although the number of components associated with the eigenmode splitter makes it complex, with no phase or magnitude adjustments made to the splitter from those theoretically required, results show very similar B_1 field profiles and phase distributions to theoretically predicted through simulations. This suggests that although the benefit of preamp decoupling is not available, the symmetry and moderate coupling of this Tx-array, allowed successful eigenmodes to be produced in the transmit mode. With the uniform quad mode contained in a single channel, protocol adjustments can be done using a single Tx-channel. Future research will include extension to Tx-arrays with not only azimuthally distributed elements but also distribution along the z-direction to allow Tx-SENSE acceleration in 2D as well as better B_1 shimming capabilities.

References

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