MRI WITHOUT B_0 GRADIENTS (Off Mainstream Techniques)

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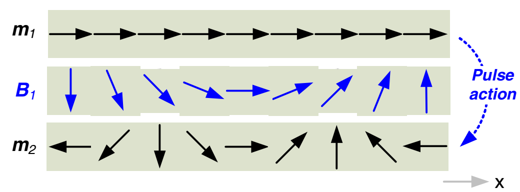
Highlights

- Mini-review of encoding approaches: "From NMR to MRI" (B_0 gradients, B_1 gradients, others)
- Concepts behind imaging with RF phase gradients ('TRASE') (TRansmit Array Spatial Encoding)
- Implementation of TRASE (design and use of RF phase-gradient transmit coils)
- Applications: micro-imaging and clinical low-field imaging.

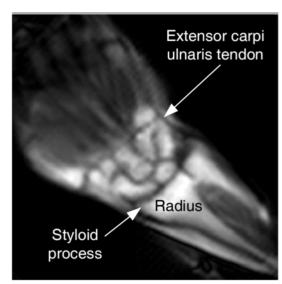
Target audience: MR Scientists; RF Engineers; Clinicians with an interest in very-low cost MRI.
Objectives: Learn the principles behind B_1 phase gradient experiments. Learn the requirements and pros/cons. When should I consider using B_1 phase gradient imaging?

Purpose: Since B_0 gradients work very well, it is often asked: Why develop alternative methods?" For TRASE, we can identify three reasons. (A): The different physics of image formation (such as a completely static B0 field) allows imaging in physical situations not previously possible; (B) the different technology (i.e. elimination of B_0 gradient sub-system) may have important practical consequences for MRI system siting/installation and for very-low-cost MRI; (C) the different pulse sequence behaviour (such as the different way k-space is traversed) may enable new experiments, quite possibly in conventional MRI systems as hybrid B_0/B_1 encoded methods.



Methods: The principles behind the B_1 encoding will be fully explained. As illustrated (left), the refocusing action of a B_1 transmit phase gradient is to introduce a spatially-dependent spin phase – i.e. k-space encoding. Importantly, the k-space encoding can be progressively increased (yielding high resolution images), by repeated refocusing with an echo train sequence. One extra detail is that the sign of the phase gradient needs to be alternated, so for each encoding axis, two different phase gradient fields are required. K-Space: As always in imaging a k-space description is illuminating. For TRASE this reveals that an RF phase gradient can be represented as an off-center point in k-space, and the refocusing action is equivalent to a point reflection about that point. These k-space trajectories will be described. Coils: The design and construction of phase gradient RF coils and coil arrays will be described.

Results: – The 0.2T image shown (left) was obtained by 2D RF-encoding in plane (third dimension encoded by B0 phase-encoding).



Discussion: - As the results show, this method is capable of producing high resolution in vivo images, but what are the limitations? The requirements for TRASE experiment are as follows:

- A single transmit channel, with a switchable array capable of producing at least two different transmit fields (at least one being a phase gradient, preferably both).
- Reasonably good refocusing action (equivalent to 160deg < flip < 200deg) – to minimize artifacts.
- Ability to produce long echo trains of short refocusing pulses - for high resolution.
- Stay within SAR limits (this is easier to achieve at lower B_0 fields; or for micro-imaging)

Conclusion: RF phase gradients offer an intriguing alternative way to perform MRI. Using this approach to develop very-low-cost MRI has the potential for large clinical impact if it could enable access to MRI for under-served patient populations world-wide.

Reference: Sharp-JC & King-SB MRM 63(1) p.151 2010.