IDEA simulator extension: a sequence analyzer

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Purpose

A new sequence analysis tool (Matlab) is presented that uses the sequence information (*.sqi) from the IDEA sequence simulator. The program enables an automatic determination of all magnetization pathways, the echo times, signal amplitude weighting and phase factors, including arbitrary gradient and rf pulse shapes, off-resonance effects, diffusion and flow effects.

Subjects and Methods

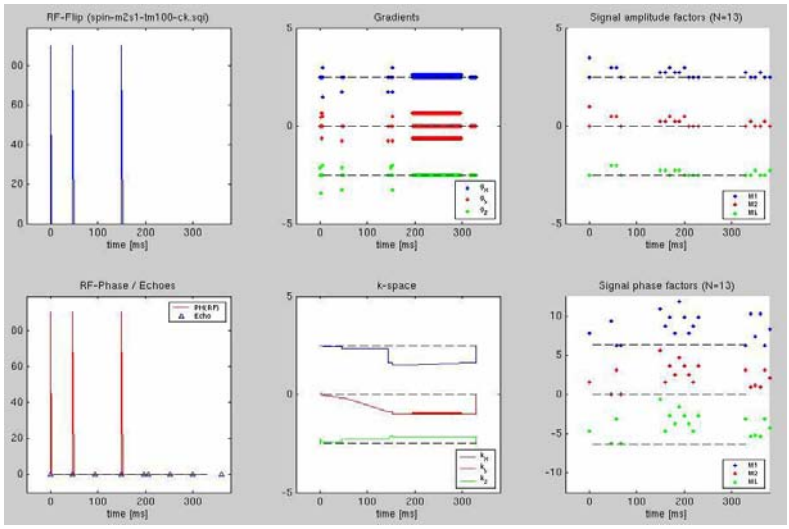
The generalized k-space concept [1] expresses the Fourier coefficients of the magnetization according to a suitable basis. As a completion to [1] the echo times are derived in a more consistent and automated way. The command tool is based on a data structure that contains the entire information on the signal amplitude and phase factors, the magnetization pathway - described by the indices of the basis (1,2,3), on which the echo occurs, and the echo times in milliseconds for every magnetization state *mi* along all paths and knots *ki*.

Results

A stimulated echo sequence with three rf-pulses (90°) and rf center times: t0= 0.11, 47.09, 149.75ms was analysed. The theoretically determined echo times are in exact agreement with the echo times derived from the sequence tool ($\tau1$ = 46.98ms, $\tau2$=102.66ms): 1) te = t0 + 2$\tau1$ = 94.07 ms, 2) te = t0 + 2$\tau1$ + $\tau2$ = 196.73 ms, 3) te = t0 + 2$\tau2$ = 205.43 ms, 4) te = t0 + $\tau1$ + 2$\tau2$ = 252.41 ms, 5) te = t0 + 2$\tau1$ + 2$\tau2$ = 299.39 ms ($\tau1$: time interval between pulse 1 and 2, $\tau2$: time interval between pulse 2 and 3).

Figure 1: Output sequence analyzer

```
mi,ki: 3,1
path-ID: 1 2
s1,s2,sz (A): 0.5,0.5,0.5
s1,s2,sz (P): 3.1416,0,3.1416
Echo: 94.07
mi,ki: 4,1
path-ID: 1 1 2
s1,s2,sz (A): 0.25,0.25,0.25
s1,s2,sz (P): 4.7124,181.5708,-85.2876
Echo: 299.39
mi,ki: 4,2
path-ID: 1 2 2
s1,s2,sz (A): 0.25,0.25,0.25
s1,s2,sz (P): 178.4292,1.5708,91.5708
Echo: 205.43
mi,ki: 4,3
path-ID: 1 3 2
s1,s2,sz (A): 0.5,0.5,0
s1,s2,sz (P): 97.854,91.5708,4.7124
Echo: 196.73
mi,ki: 4,4
path-ID: 2 1 2
s1,s2,sz (A): 0.25,0.25,0.25
s1,s2,sz (P): 1.5708,178.4292,-88.4292
Echo: 252.41
mi,ki: 4,5
path-ID: 2 2 2
s1,s2,sz (A): 0.25,0.25,0.25
s1,s2,sz (P): 181.5708,4.7124,94.7124
Echo: 252.41
mi,ki: 4,6
path-ID: 2 3 2
s1,s2,sz (A): 0.5,0.5,0
s1,s2,sz (P): 97.854,91.5708,4.7124
Echo: 149.75
```



Conclusion

The new Matlab software package is an outstanding extension to the IDEA sequence simulator. It provides all necessary information on the magnetization behavior with respect to the simulated sequence parameters.

References

[1] Nelson,R.et al.: Counting echoes: application of a complete reciprocal-space description of NMR spin dynamics. Concepts in Magnetic Resonance, Vol 10(6) 331-341 (1998).