New Insights into PET Count Rate Reduction during Simultaneous MR-PET Measurements

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Introduction

Minor influences of MRI on the PET detectors during simultaneous MR-PET measurements with the 3T MR-BrainPET (Siemens Healthcare, Erlangen, Germany) have been observed[1].

Further studies revealed that simultaneous MRI might reduce the measured PET count rate by up to three percent [2]. The reduction has been shown to depend linearly on gradient rise time and amplitude. It also increases with a shorter repetition time [1,2]. Here, we report on more detailed examinations targeting the origin of the PET signal distortions induced by the varying magnetic fields.

Methods

Dedicated MR sequences have been developed in order to describe the macroscopic effect of count rate reduction during simultaneous MR-PET measurements (for details cf. [1]). They allow for a separate analysis of the influences of RF pulses and MR gradient fields with a detailed definition of parameters (e.g. amplitude, rise time and repetition time). The analogue PET signals (scintillation pulses and baseline) of a single detector block after pre-amplification and pulse shaping were observed with an oscilloscope during the execution of the aforementioned custom MR sequence (All gradients active, TR=2.5ms; G_{max}=20mT/m; gradient duration of 1ms; rise times of 6.5 and 20 µs/(mT/m)*)*. Additionally, the MR gradient waveform was measured and served as a trigger signal for later measurements. The received signal was averaged over 1024 trigger cycles.

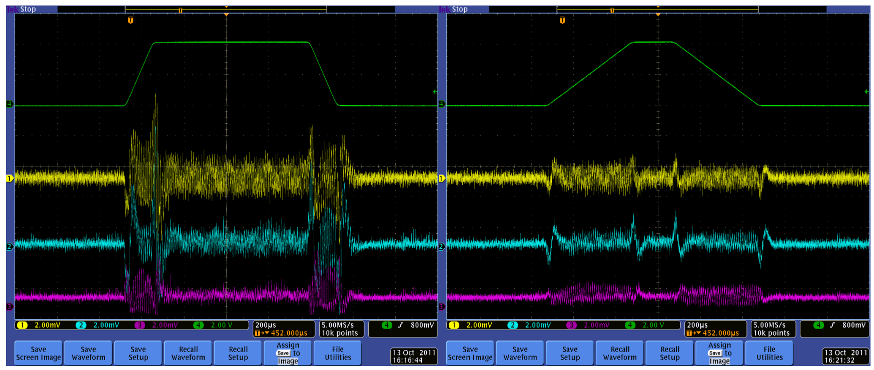

Figure 1*: Measured PET signals (yellow, cyan, magenta) and gradient waveform (green) for two experiments with 6.5 µs/(mT/m)(left) and 20 µs/(mT/m)(right) risetime.*

Results

Fig.1 shows analogue PET signal distortions. . It is evident that the PET baseline signal becomes distorted with the start of the gradient events. It is noteworthy that the largest effect was observed on the start and end of the gradient ramps, which strengthens the hypothesis of the effect being created by eddy currents. We did also observe an increased noise level during the gradient flat top. Fig. 2 shows a smoothed average of the PET signals and their frequency spectrum. Characteristic frequency peaks are visible at 0.1 and 0.2 kHz. The large spikes caused by gradient switching are assumed to be responsible for the count rate drop. Further measurements indicate no influence of RF pulses on the PET signal, neither increased baseline nor distortion of scintillation events.

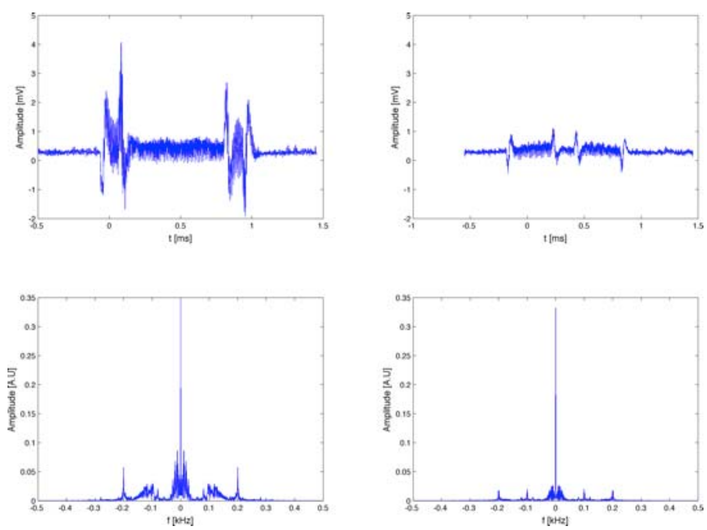

Figure 2: *PET signals for the two experiments and their frequency spectrum.*

Conclusions

The analysis presented here provides insight into the process causing the observed count rate drop and should be considered in the design of new PET detectors and processing electronics.

References

[1] Kaffanke et al. Proc. ISMRM#3951 (2010)
[2] Weirich et al. Proc. ISMRM #3796 (2011)