Reference coils signal combinations removes gradient switching artefacts in physiological recordings during MRI

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Introduction

Performing physiological registrations simultaneously with MR scanning of a subject is technically demanding and usually requires the removal of a huge gradient switching artefact from the weak physiological signal. The artefacts are caused by induction in the unavoidable loop area of electrode leads. The gradient switching signal is highly dependent on the position and orientation of the electrode leads loop and consists of contributions from all three gradient field components (dG_x/dt, dG_y/dt, dG_z/dt).

Aim: To investigate a concept with reference coils for simultaneous gradient switching registration for artefact removal.

Material and methods

The measurements were performed on a Philips Achieva 3.0T magnet (Philips Medical Systems, Best, The Netherlands) and an ADC by Data Translation (Marlboro, Massachusetts, USA) with 50 kHz sampling frequency and 12-bit signal depth. A custom-made 100 turn pick up coil was used for measuring the reference signals and a custom-made 10 turn coil for mimicking the loop area of electrode leads.

The three reference signals were measured at the rear of the magnet at different positions inside the bore, but outside the scanning volume and outside the linear gradient region (Fig. 1). This set-up allows more possibilities for placing the reference coils and leaves more space for the patient and minimizes patient interference with the coils. Artefact signals mimicking physiological recordings were obtained at four different positions and angulations between the hand to knee region of a patient in supine position in the magnet. A standard phantom was placed in the head coil for the duration of the measurements.

A code was implemented in Matlab to match the reference signals with the mimicked signal by finding the linear combination of the three reference signals that minimized the artefact signal.

Results and discussion

The gradient switching artefact was successfully minimized in all four signals with linear combinations of the reference signals (Table 1).The less than optimal artefact suppression and the remaining ringing artefact seen in Fig. 2 was likely caused by insufficient fixation of the pickup coils. Mechanical vibration caused by the gradient switching as well as very small changes in coil position and angulation can not be ruled out in the setup used. This demonstrates the importance of avoiding any vibration or motion in the pick up coil setup.

Minimizing of gradient switching artefacts, induced in a loop in the hand to knee region of a subject in a MR scanner is possible with reference recordings from three pick up coils at different position. The gradient artefact can be minimized by adding the correct linear combination of the reference signals. The presented method works with any pulse sequence and any position and geometry of electrode leads loop.

	Reference 1	Reference 2	Reference 3
Signal 1 (Fig. 2)	0.0499	-0.0470	-0.0282
Signal 2	0.0338	-0.0335	-0.0289
Signal 3	0.0532	-0.0028	0.0110
Signal 4	-0.0084	0.0524	0.0160

Table 1: The linear combination coefficients for a minimized gradient switching artefact.

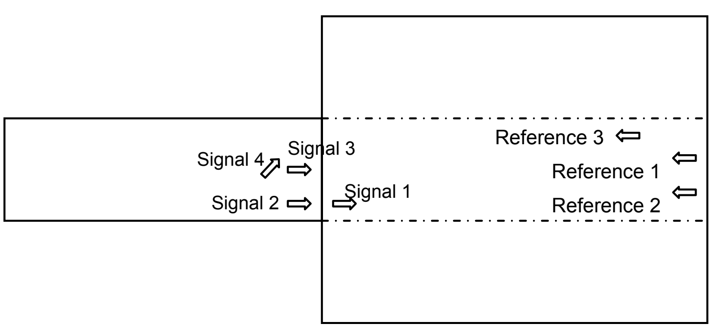

Fig. 1. Sketch with the approximate positions and angulations of the three measurement coils on the rear of the magnet and measurement coils in the front of the magnet.

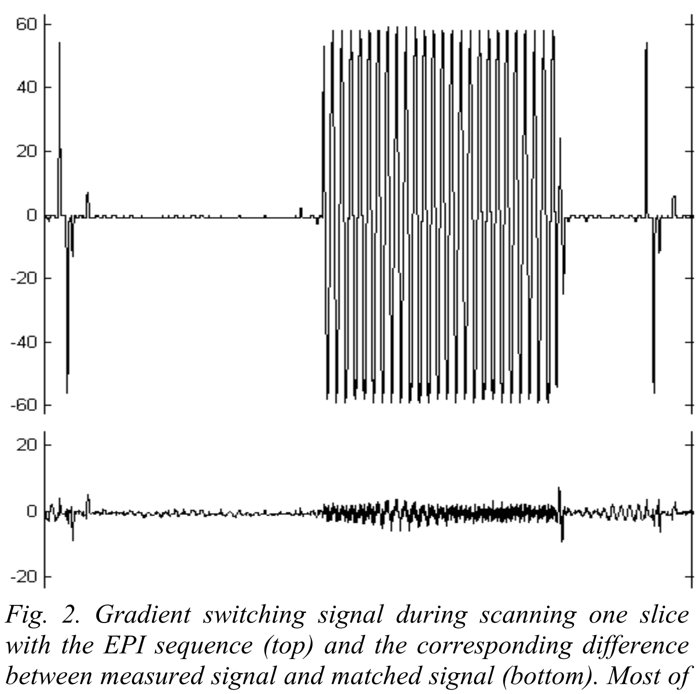

Fig. 2. Gradient switching signal during scanning one slice with the EPI sequence (top) and the corresponding difference between measured signal and matched signal (bottom). Most of the remaining artefact is due to one of the reference recordings having an oscillation on the baseline (due to vibration of the coil).