Usage of birdcage coil harmonic frequencies for measurement of respiration induced impedance changes

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Audience: MR scientist or engineer

Purpose: As shown in [1], respiration induced impedance changes (RIIC) in a birdcage coil can be acquired by reflected power measurements during RF transmission. The dependence on the excitation pulse however limits the sampling and data rate. In this work, we investigated whether continuous measurement of the RIIC could be performed with the usage of a harmonic frequency of the birdcage coil.

Method: The resonant spectrum of a 3T MRI birdcage body coil (GE Healthcare, Waukesha, WI, USA) was measured with a network analyzer (Rohde&Schwarz, Munich, Germany). The S11-characteristic and Q-values of the harmonic modes were analyzed. An external RF source (PTS Inc., MA, USA) was connected to the I-port of the body coil, while the Q-port was terminated. A frequency multiplier and amplifier (MiniCircuits, NY, USA) were used to generate the different frequencies with a constant power at the coil of P_{FWD}=10mW. The reflected power was measured with a power sensor (R&S) via a directional coupler. The effect of the impedance change caused by a moving CuSO4-phantom was evaluated for the some harmonic frequencies [Fig 1]. The best correlation between impedance change and reflected power (best Q-value) was measured at a frequency of 235MHz besides the 1H-frequency. This frequency was used to measure RIIC on a healthy subject in the birdcage coil. For comparison, the information of the pneumatic belt was also saved. The data were filtered and processed in Matlab (Mathworks, CA, USA).

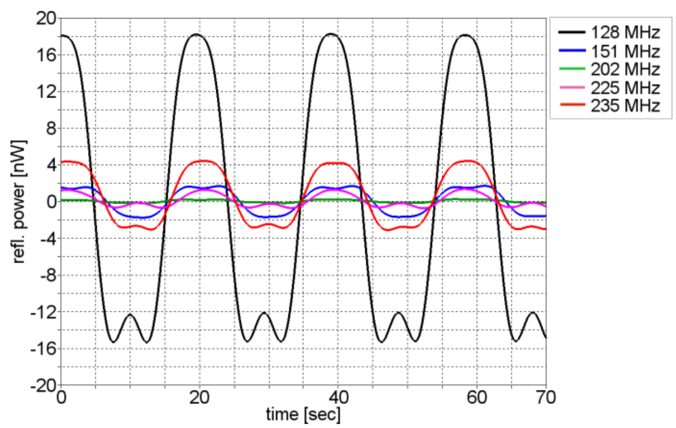

Figure 1: Reflected power of some harmonic frequencies during phantom movement.

Results: The RIIC measured at 235MHz shows good correlation (R^2=0,73) to the respiratory belt data [Fig2]. Due to a lower Q-value of the harmonic frequencies, the reflected power changes are not as dominant as on the tuned 1H-frequency. However after filtering on the respiration frequency of 0.1Hz and normalization of the data, the RIIC was detected reliably and magnitude differences between normal and deep breathing were distinguished.

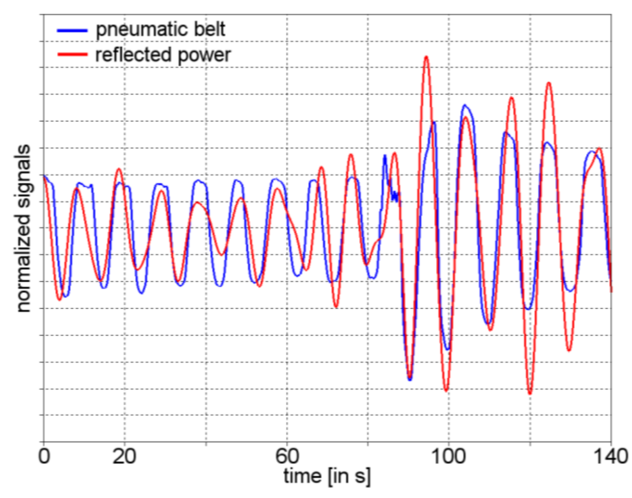

Figure 2: Comparison of the normalized pneumatic belt data (blue) and reflected power at f=235MHz (red) during normal breathing (0-90sec) and deep breathing (90-140sec).

Discussion: With the usage of birdcage coil harmonics, no additional sensors inside the magnet room or on the patient itself are needed to detect respiratory movement. In addition, the continuous acquisition of the reflection changes on a harmonic frequency allows a high resolution sampling of the RIIC, which can be used for motion correction. For synchronous imaging and RIIC measurement, a fast switching unit (pin-diode circuit) is currently in development to prevent the measurement setup from the high power of the 1H-excitation pulse.

Conclusion: The usage of birdcage coil harmonics for RIIC measurement was shown. To our knowledge, this work is the first demonstration of RIIC using birdcage coil harmonics. Further work will be necessary to allow imaging during the measurement and to acquire and analyze cardiac induced impedance changes [1] for motion correction or triggering.

References: [1] Buikman et.al., [1988], MRI 6(3):281-289