Utilization of the receive coil for cardiovascular and respiratory motion representation

Guido P. Kudielka[1,2], Christopher J. Hardy[3], Pierre-André Vuissoz[1,4], Jacques Felblinger[5,6], and Anja C.S. Brau[7]
[1]*Imagerie Adaptative Diagnostique et Interventionnelle, Université de Lorraine, Nancy, Lorraine, France,* [2]*GE Global Research, Munich, BY, Germany,* [3]*GE Global Research, Niskayuna, NY, United States,* [4]*U947, INSERM, Nancy, Lorraine, France,* [5]*CIC-IT 1433, INSERM, Nancy, Lorraine, France,* [6]*University Hospital Nancy, Nancy, Lorraine, France,* [7]*GE Healthcare, Munich, BY, Germany*

Audience: MR scientist or engineer interested in RF engineering and motion sensing

Purpose: Bringing an MRI coil into proximity with a subject causes changes in the impedance and Q-value of the coil due to the electromagnetic influence of the load. These impedance changes can be measured by the power level of a reflected RF signal. This information can be used to track motion-related position changes of organs[1]. In this work, we show that MRI receive (Rx) coils can be used for detection/measurement of respiratory motion, heart motion and pulse wave velocity (PWV).

Method: A Rx loop coil with 75mm diameter was constructed, tuned and matched to 128MHz. This coil was placed in various positions over the chest of a healthy volunteer, simulating different elements of a multi-channel Rx coil for 3T (Fig.1). The motion measurement system consisted of a signal generator and a bi-directional coupler. A continuous RF signal with a power of 10mW and a frequency of 128MHz was transmitted from the source. The coupled reflected power was acquired by a power meter (NRP-Z11, Rohde & Schwarz, Germany). A LabView (National Instruments, TX, USA) application performed low-pass filtering and transferred the signal via a 10-bit digital-analog-converter to the Signal Analysis and Event Controller (SAEC) system[2]. This system recorded the coil data with ECG, peripheral pulse (PPG) and respiratory belt data simultaneously. The acquired data were processed with Matlab (Mathworks, MA, USA). The time between the R-wave of the ECG and the beginning of the next upslope of the reflected power signal was measured for coil position 2 and 3. PWV was calculated by the ratio of the distance between positions 2 and 3 and the time difference of both power signals.

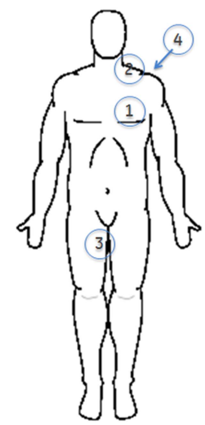

Figure 1: Coil positions

Results: Fig.2 shows the raw data of the reflected power measurement at position 1. Here respiratory and cardiac motion are clearly visible as low and high frequency components, respectively. The cardiac motion can be extracted with a filter and correlates with the ECG (Fig.3). In comparison, on the posterior side of position 1 (position 4) the breathing motion was dominant, with no measurable component at cardiac frequencies. positions 2 and 3 appear to show primarily the pulse profile of the blood flow in the arteria subclavia and arteria femuralis respectively (Fig.4 and Fig.5). The calculated average PWV between positions 2 and 3 was 4.5 m/s, which is consistent with literature values[3].

Discussion: The impedance change of a receive coil can be used to measure different physiologic motion events during an MRI scan. Due to image acquisition and RF transmission, the impedance measurement would need to be interrupted; however, the excitation and acquisition windows are usually short compared with the TR time and missing impedance data could be interpolated. Setup improvements in terms of sensitivity and sampling rate are necessary to increase reliability of the measurement.

Conclusion: We show that by measuring impedance variations on Rx coils, cardio-respiratory information can be acquired. This may be of interest when classical sensors as ECG or pneumatic belts do not perform well, especially in ultra-high field systems or in pediatric imaging. Besides respiratory or cardiac motion, additional information like PWV can be acquired as well and give extra physiological information without extending the exam, and without use of additional measurement devices. Future work will include in-table coils and parallel acquisition of multiple channels for spatially localized motion models and to measure PWV without additional reference.

References: [1] Buikman et.al. MRI 1988:Vol 6(3):281-289; [2] Odille et.al. IEEE Trans. Biomed. Eng. 2007 Vol45:630-640; [3] Boutouyrie et.al. Eur. Heart Journal 2010: Vol 31, 2338-2350.

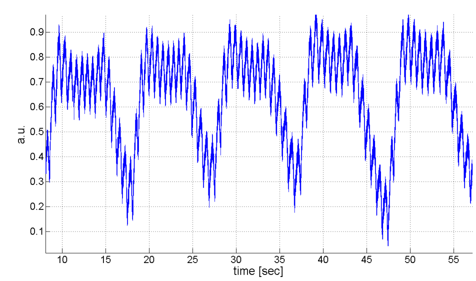

Figure 2: Reflected power measured at position 1, unfiltered.

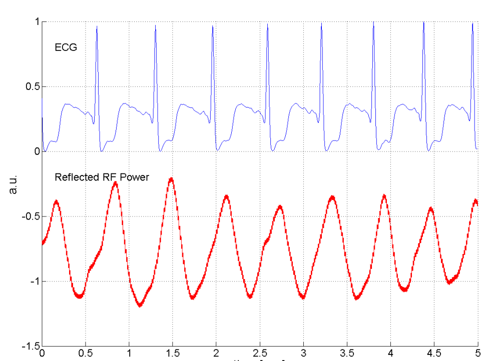

Figure 3: Reflected power signal at position 1 after filtering (red) in comparison with ECG (blue)

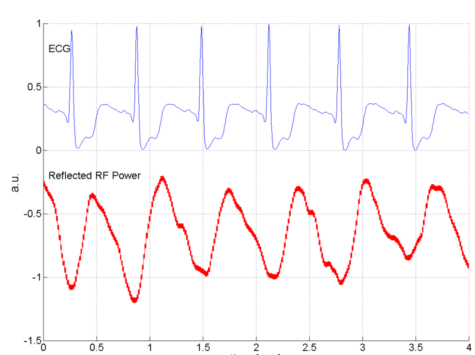

Figure 4: Reflected power signal at position 2 (red) in comparison with ECG (blue).

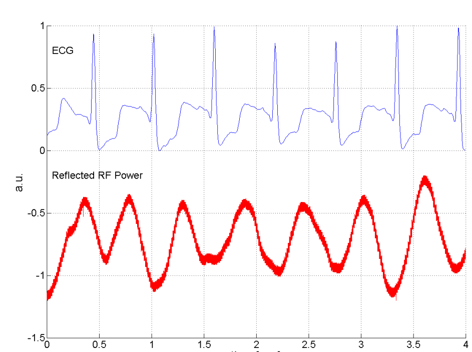

Figure 5: Reflected power signal at position 3 (red) in comparison with ECG (blue).