

# A sequence controlled RF pulse switch at 7T for PASL with an external labeling coil

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## Introduction

Arterial spin labeling (ASL) for quantification of cerebral blood flow (CBF) can offer several advantages at high field like prolonged T1 and higher SNR. On the other hand several challenges at 7 Tesla and beyond like B<sub>1</sub>-inhomogeneity and SAR limitations are to be addressed. The use of separate imaging and labeling coils can reduce the RF power deposition in the brain area while completely eliminating magnetization transfer (MT) effects.

Using a separate labeling coil usually requires a fully equipped additional RF transmit path which comprises a synthesizer, modulator, power amplifier and a special interface controller. Here, we present a different solution which uses a RF power switch, which is transparent for the scanner during transmit and receive. It is solely controlled by any pulse sequence at run time and can produce any labeling pulse shape and timing scheme the ASL imaging sequence is capable of.

## Material and Methods

An in-house developed fast RF power switch was used to reroute RF pulse power, usually delivered from the scanner's power amplifier to the imaging coil directly, to an external labeling coil (Fig. 1). At run time the RF power transfer to a custom built separate labeling coil was controlled by the imaging sequence, which simultaneously activated this coil and deactivated the imaging head coil. All other control lines were transferred through the switch to the imaging coil unaltered.

**Phantom data:** A custom made hollow PLEXIGLAS<sup>®</sup> sphere, diam. 17 cm, containing tap water, was used as a head phantom (Fig. 3). A polyethylene tube, inner diameter 3 mm, wound into 2 turns, diameter 14 cm, was placed inside the spherical phantom. This tube was also fed tap water at a low velocity of 30 cm/s. A separate labeling coil (1 turn, diameter 60 mm) was located outside the head phantom at a position 12 cm from the isocenter at the optimum position for labeling one of the brain feeding arteries.

### Phantom measurements:

ASL-MRI was performed on a 7 T whole body scanner (Magnetom 7 T, Siemens Healthcare, Erlangen, Germany) using a standard 24-channel head coil (Nova Medical, Wilmington, MA, USA). A STAR sequence was modified so that the saturation pulse, carried out by the imaging volume head coil, was immediately followed by the inversion pulse to the external labeling coil (Fig. 2). The sequence parameters were: TR = 10 ms, TE = 4 ms, TI = 300 ms, alpha = 13°, inversion pulse length = 15 ms, inversion pulse voltage = 35 Volts, slice thickness = 40 mm, inversion slice thickness = 80 mm, inversion slice distance = 12 cm from isocenter, flow velocity = 30 cm/s, saturation slice thickness = 60 mm, 10 averages, acquisition time 11m19s, 30 images, time resolution = 70 ms. The readout sequence was a segmented FLASH sequence with centric reordering.

## Results and Discussion

After appropriate timing and adjusting of all pulse voltages phantom measurements (Fig. 3) showed images of water flow with high contrast and over periods of more than 1 s after labeling. Control directly by the running sequence allowed for easy adjustments of time intervals and inversion pulse power. As pulse shape generation is independent from external pulse shaping equipment, pulsed and pseudo continuous ASL can benefit from using this scheme. The high power inversion pulse is replaced by a low power RF pulse which decreases SAR and offers flexibility in pulse design using the sequence development environment of the scanner.

## References

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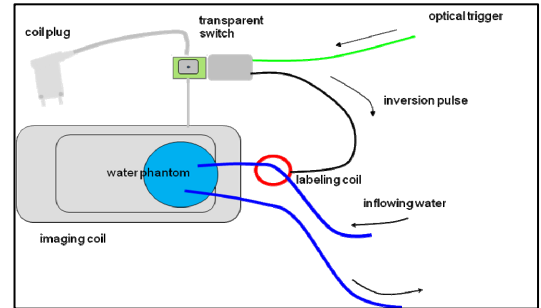


Fig. 1: Schematic of the experimental setup. A sequence generated optical trigger switches RF power from imaging to labeling coil and back. Saturation and imaging pulses are routed through the switch to the imaging coil when the labeling coil is inactive.

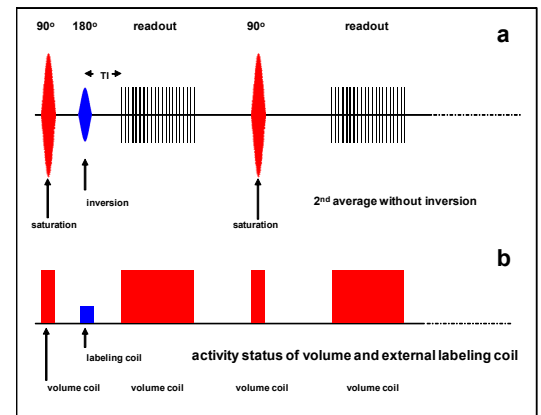


Fig. 2: a) Timing of the used STAR imaging sequence. Changing the activity status of imaging coil and external labeling coil is shown in b). The second average without inversion pulse was used for subtraction to suppress background signal.

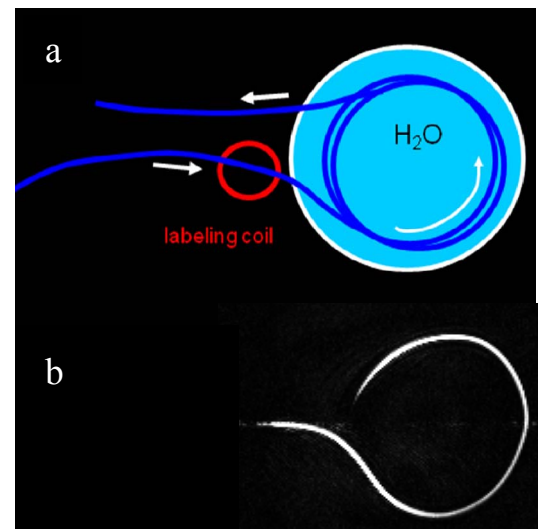


Fig. 3: a) Inversion of the incoming water flow by the labeling coil. A polyethylene tube formed two turns inside the water filled sphere. b) Coronal image of labeled water in the phantom. Acquisition time was 11m19s. The displayed length of water flow is equivalent to more than 1 s flow at a flow velocity of 30 cm/s. The distance from the center of the labeling coil to the center of the water phantom was 12 cm.