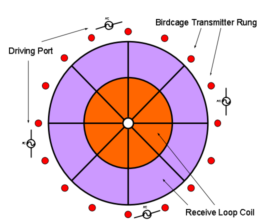
A 3T Head Transmitter Integrated with 3D Parallel Imaging Capable 16-Channel Receive Array Coil

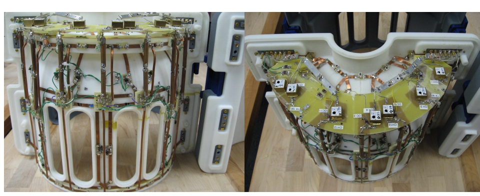
H. Fujita[1,2], T. Zheng[1], and X. Yang[1]

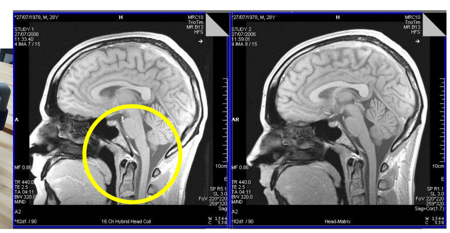
[1]Department of Physics, Case Western Reserve University, Cleveland, Ohio, United States, [2]Department of Radiology, University Hospitals of Cleveland, Cleveland, Ohio, United States

Introduction In 3T head imaging, 3D MRA, fMRI and neuroimaging as well as the routine clinical applications are of high interest. Transmitting B_1 by a large whole body coil requires a high input voltage, on the order of 210V, for typical head imaging. On the other hand, utilizing a local and much smaller transmitter coil targeting a specific FOV requires less input voltage, 140V, in the case of the integrated T/R parallel-imaging capable head coil reported herein; thus, the integrated T/R coil is more effective from a standpoint of power requirement. This also means that achieving higher B_1 is enabled by the use of a localized transmitter coil so that applications such as 1H spectroscopy can be more effectively explored.

Methods The coil, designed for the Siemens 3T MAGNETOM Trio with TIM MRI system (Erlangen, Germany), consists of a transmitter QD 16-rung high-pass birdcage coil with its diameter 29cm and length 29cm, and an array of 16 independent receive-only loop coils, two rows of 8 loop coils in z, located at the inner dome-shape tube whose length is 27cm and diameter 26.5cm, 1cm larger than the diameter of the Siemens TIM 12-channel head matrix (12 loop coils arranged in a single row, i.e., 2D). The birdcage coil is driven at 4 ports (0, 90, 180 and 270) in order to assure the B_1 transmit uniformity and symmetry at 3T. The transmitter and the receiver sides, all tuned and matched at 123.2MHz, are interfaced via a T/R switch. A schematic representation from a bird's-eye view is given in Figure 1, and the anterior electronics shown in Figure 2. Although not shown, the adjacent receive loop coils are appropriately overlapped to minimize the mutual inductance coupling among them. The worst isolation was measured to be approximately -11dB. In addition, each loop coil has an integrated low noise figure (<0.5dB) and low input impedance (<3Ω) preamplifier for preamplifier decoupling. To address a higher number of receive channels, which is the current industry trend, we have also developed a micro-size non-magnetic preamplifier whose size is merely 1.3cm by 1.3cm by 9mm. Thus, integrating preamplifiers to the coil circuits does not result in unwanted effects coming from the preamplifiers just located above or in the vicinity of the FOV when each loop coil size becomes smaller. Each size of a loop, approximately on the average 12cm by 15cm, is optimized, depending upon its location relative to the head (i.e. larger elements at the posterior side to enhance the SNR in the deep brain regions). To house the aforementioned electronics, we have designed a mechanical housing, a split-top design, as shown in Figure 3, using SolidWorks™ 2006. This coil also provides two receive modes; one for the upper brain mode targeting fMRI applications shown in orange (Fig.1) (the upper 8 receive loop coils activated) and another for the full head mode shown in orange and purple (both the upper 8 and lower 8 receive coils activated) to support the entire clinical head imaging applications. This design allows 3D parallel imaging capability, which is essential for applications such as 3D-MRA and TOF.







[From left to right in sequence] Fig. 1 Bird's-eye view of the projection of the T/R 16CH head coil onto the x-y plane. Fig. 2 Electronics of the T/R 16CH head coil (front and top). Fig. 3 Split-top design Fig. 4 T1_fl2d_sag_320_3mm: T/R 16CH head array coil (left) and 12CH head matrix coil (right); a circle in yellow exhibiting better caudal homogeneity achieved by strategically positioned larger posterior loop coils.

Results We conducted a series of studies, in particular, SNR-critical applications based upon different sequences using different weightings/contrasts/orientations/slices, and compared the T/R 16-channel head coil with the 12-channel head matrix coil. As shown in Fig. 4, the both coils performed rather similar to each other with some distinct differences. First, the 16-channel head coil is a T/R coil, capable of both transmission and reception, gaining the aforementioned advantages. Second, the 16-channel head coil offers a brain mode targeting fMRI applications and a full head mode for the entire head clinical imaging applications. Finally, the 16-channel head coil has an additional parallel imaging capability in head-feet direction which is useful for e.g. TOF applications.

Conclusions The integrated transmitter with 16-channel receive head coil was built, tested and compared with the Siemens TIM 12-channel head matrix. While the both coils provide the equivalent performance, the 16-channel head coil, in addition, offers the transmission capability, two modes of brain and full head, and 3D parallel imaging capability.

References [1] Y-J. Yang, et al., "An Optimized 16-Element Head Coil for 7T with Integrated Preamplifiers," ISMRM Proceedings 420 (2006)

Acknowledgements The authors thank Dr. Hubertus Fischer and Wolfgang Risse at Siemens Medical Solutions for their support and invaluable discussions in this study.