Transmit / Receive Single Echo Imaging

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Introduction:

Single Echo Acquisition (SEA)[1] uses only one echo for an image and is thus capable of high speed imaging. Using this technique, a rate of 1000 frames per second was successfully shown [2]. In SEA imaging, a volume coil is used to excite the sample to be imaged. 64 long and narrow coils are used for receiving. Because the voxel size is the same as the coil size in the "phase encoding" direction, a phase compensation gradient is necessary [3]. Because of this requirement, current configuration is limited to planar array. When a single coil is used for both transmitting and receiving (TR mode), phase imparted during transmitting is "refocused" during receiving, thus eliminating the need for phase compensation gradient.

A 64 channel parallel transmitter and TR switches were constructed. Combined with the receiver [4], converting the receive only SEA (RO SEA) into a Transmit / Receive SEA (TR SEA) system. Combined with flexible SEA coil array wrapped around the surface to be imaged, a single shot for the curved slice excitation followed by a single echo yield an MR image on that curved surface.

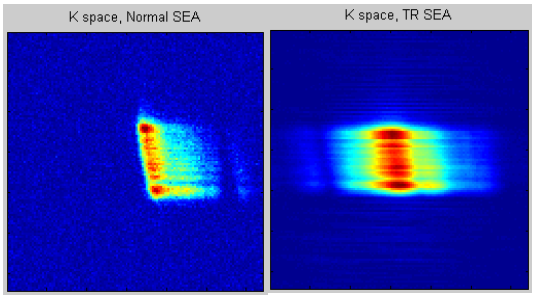

Figure 1 K-space shift with RO SEA and TR SEA

Methods and Results:

To verify that the no phase compensation gradient is needed for TR SEA, a single element SEA coil is used for a gradient echo image. In the first experiment, a volume coil is used for transmitting, and the SEA coil is used for receiving. A fully encoded image is acquired. The k-space is shifted from the center, as shown in the left picture of figure 1. When the same coil is used for both transmitting and receiving, using the same imaging parameters, the k-space is shifted back to the center, as shown in the right picture of figure 1. The signal to noise ratio has a factor of 7, comparing the two cases.

A 64-channel parallel transmitter was designed and constructed [5] to upgrade the RO SEA system into TR SEA system. The transmitter features 64 vector modulators, driven by 128 digital potentiometers for in-phase and quadrature modulation. 64 digital controlled attenuators for rough level control, 64 preamps and 64 driver amplifiers are used to feed 64 partial microstrip matched MOSFET based amplifiers for 100W output from each channel. 64 TR switches are also constructed using standard design to connect to 64 preamps and 64 receivers that have already been in service in the lab.

To verify the performance of the transmit pattern, a "reverse SEA" setup was first implemented. The 64 channel SEA array is used for transmitting, while a volume coil is used for receiving. A flexible SEA coil array is wrapped around a cylindrical phantom, as shown in figure 2. The whole setup is put inside a birdcage coil for receiving. An axial image (figure 3) is taken, showing the excitation pattern. Note that this transmit pattern does not require gradient involved, with a single shot.

With the same setup as the "reverse SEA" except that volume coil removed, the system is used for TR SEA imaging. This image is taken using a single shot excitation, and a single echo acquisition. A rectangle and three squares are attached to the inside of a cylindrical water container as phantom. TR SEA image is shown in figure 4.

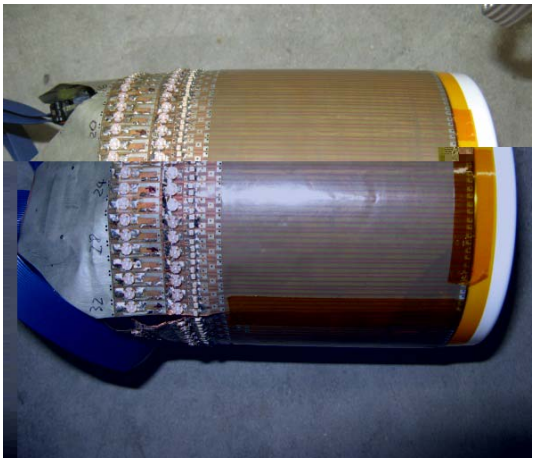

Figure 2 Photo of flexible array

Conclusions and Discussions:

TR SEA is capable of high speed surface imaging, using flexible arrays. This allows possible imaging of non-repeatable high speed event, such as BOLD image, or turbulent flows.

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References:

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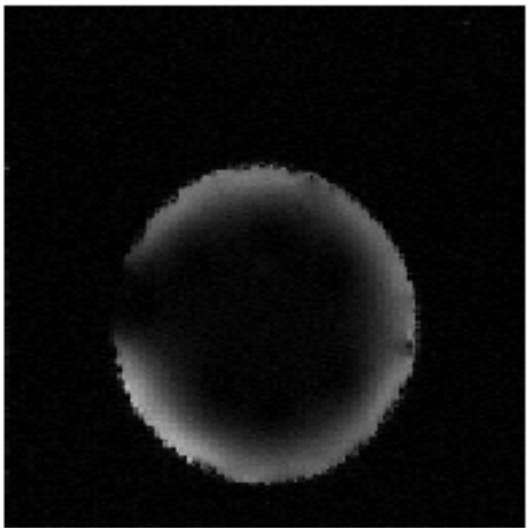

Figure 3 Single shot curved slice excitation without gradient

Figure 4 TR SEA image of surface of a cylindrical phantom, single shot curved slice excitation and single echo receiving