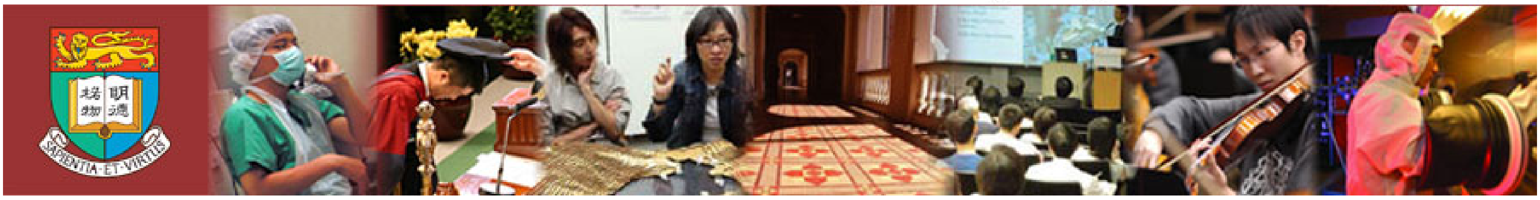

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Engineering Design of Phased Array EPI using TDM

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Introduction

Phased array coil has been successfully used in MRI to obtain high SNR over a large FOV (1-2). Multi-coil time domain multiplexing (TDM) has also presented itself as a cost effective approach to phased array imaging with no degradation in image quality (3). However, there are difficulties in performing TDM phased array coil on EPI because in EPI, much faster sampling rate and higher sensitivity of phase shifts can significantly cause signal distortion and image ghost (4). This study introduces an engineering design of crystal, surface acoustic wave (SAW) band-pass filters and a controlled phase correction method.

Methods

1. Phase Correction:

In EPI, the source of N/2 ghosting artifacts can be the phase difference between even and odd lines of the data. When applying TDM, the difference of phase shifts is getting more serious, because signals in the different channels are sampled in the different time slots. We propose to use a special variable delay line to correct the phase difference between channels. This delay line can be controlled by a non-linear gradient waveform as shown in Fig.1. Switching control signal (SWC) and A/D conversion are generated according to the sampling signal from the system controller.

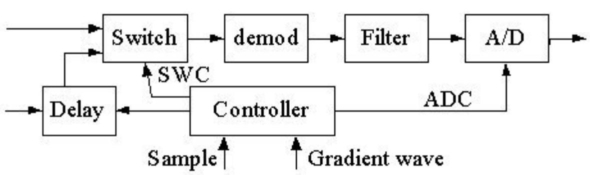

Fig. 1. Block diagram of two channel phased array EPI using TDM

2. Crystal and SAW Band-pass Filters:

Band-pass filters (BPFs) are required to replace low-pass filters for use with TDM in MRI (3). In EPI, the design and implementation of a wide BPF with high Q and sharp roll-off are not trivial. A LC filter could not achieve high Q due to high loss of lumped elements. A crystal filter has high Q and good roll-off, but is limited to 10 kHz maximum. A SAW filter is possible, but it is too expensive for a special custom design. In order to approach a 400 kHz bandwidth, we have designed a Four-pole single section with the third mode crystal BPF as shown in Fig. 2.

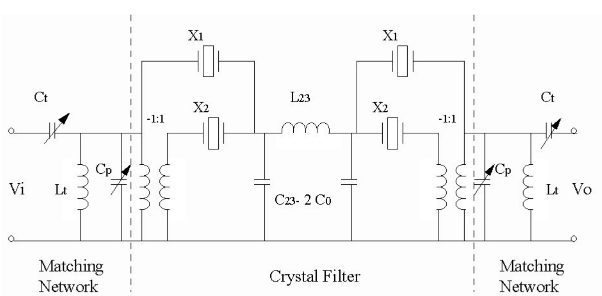

Fig. 2. A four pole, third mode band-pass crystal filter for TDM phased array EPI

SAW BPFs give very high performance. Typically, they can approach 0.8% to 0.05% of fractional bandwidth, 1.3 of shape factor and 60 dB side-lobe rejection as shown in Fig. 3.

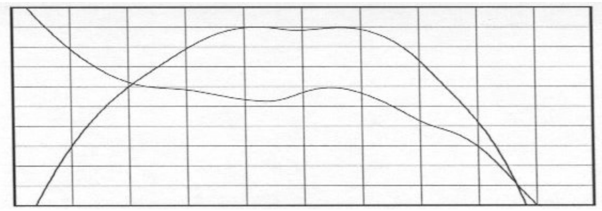

Fig. 3. 70 MHz low-loss SAW filter: 100 kHz/div (horizontal); 1dB & 5 deg/div (vertical)

However, SAW BPFs for use in MRI are not commercially available. We first modulated RF up before the BPF and then modulated RF down after BPF, thus the commercial SAW can be used for our RF signal processing as shown in Fig. 4.

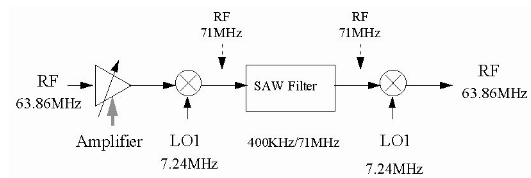

Fig. 4. Modulation RF to use SAW band-pass filter in 1.5 T

Results and Discussion

Four-pole crystal BPF can approach 400 kHz bandwidth, but its flatness in the bandwidth can be up to 25% fluctuation. Another drawback of this new crystal filter is its phase non-linearity which causes the maximum delay of 30 µs compared to 2 µs using SAW BPF in the same bandwidth. Imaging simulations show that the N/2 imaging ghost is very sensitive to the phase shift due to the performance of BPF. With SAW BPF and controlled variable delay line, such ghost artifacts of phased array EPI can be minimized. The EPI breast image is shown in Fig. 5 using two channel phased array with TDM method. Custom SAW can be designed for commercial MRI, thus further improvement of SNR is possible due to the elimination of "up" and "down" modulations.

FIG. 5. Dual-channel breast EPI, gradient echo, voxel size 3.125 X 3.125 mm (TE=50 ms, TR=1,000 ms, 90o tip, FOV=40 X 20, acquisition matrix = 128 X 64, slice thickness/gap=5/1 mm, over sampling rate at 800 KHz)

References

1. P. Roemer et al., Magn. Reson. Med. 16, 192-225, 1990.
2. C.E. Hayes et al., Magn. Reson. Med. 18, 309-319, 1991.
3. J. Porter et al., Magn. Reson. Med. 32, 499-504, 1994.
4. J. Wu et al., Proc. ISMRM, p. 61, 1997.