Wavelet-based Mode-Scanning Excitation (MSE) for Selective Excitation at High Field

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INTRODUCTION Generally, SNR of MRI linearly increases with static magnetic field (1). However, it has been shown that in high field (7T), the regional brightening caused by "dielectric resonance" may result in some above-linear SNR increase over the brightened region (2), of course at the cost of other regions under-performance in terms of SNR. Mode-scanning excitation (MSE) was introduced to achieve such above-linear SNR increase over desired region (3). However, in MSE, many sinusoidal modes suffer from low efficiency in transmission which reduces the effective resolution of this method. Wavelet-based MSE successfully resolves this issue. It can guarantee that every wavelet mode can be efficiently excited.

METHOD Since the major cause of the low efficient transmission for certain sinusoidal modes is the current cancellation between adjacent elements, we define a first-order estimation efficiency factor

$$\eta = \sum_{p=0}^{n-2} \left| I(p) + I(p+1) \right| \qquad [1]$$

Where n is the number of elements in a volume strip array (VSA), p is the port index of the VSA, $I(p)$ is the normalized current distribution in port-space. The 1st sinusoidal mode (not 0th mode) has the maximum η=1.962, and n/2 mode has the minimum η=0, where the adjacent current has the same amplitudes but opposite phase. To assure each transmit mode can efficiently deliver power to samples, our criterion for effective excitation is: η>1.5.

Daubechies complex wavelet (4) (Fig. 1 A) as well as its shrunk (Fig. 1B) and expanded (Fig. 1C) set were chosen to serve as base excitation modes. Note that seven out of 16 original Daubechies wavelet meet η>1.5. Six out of 16 and seven out of 16 of its shrunk and expanded sets meet η>1.5. Note that the shrunk Daubechies wavelet is just a slight deviation from the sinusoidal bases used in Ref. (3).

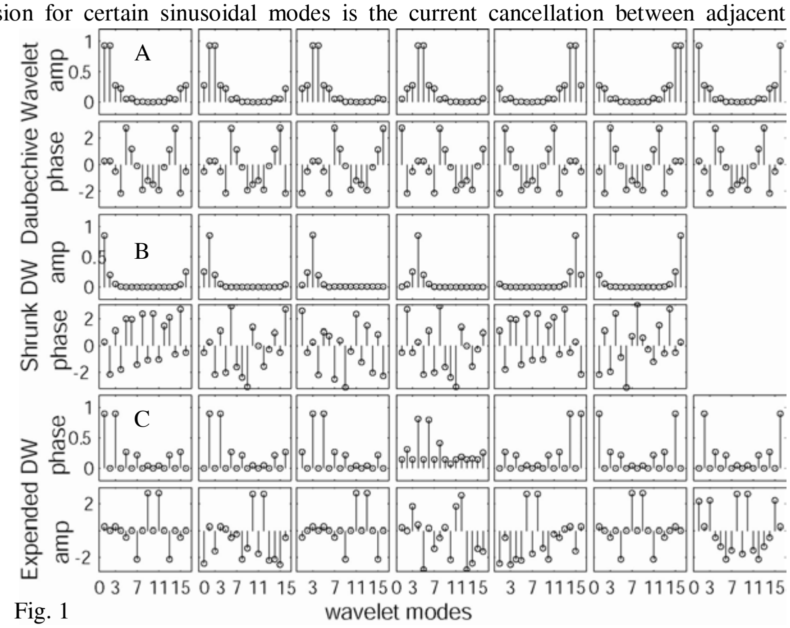

Fig. 1

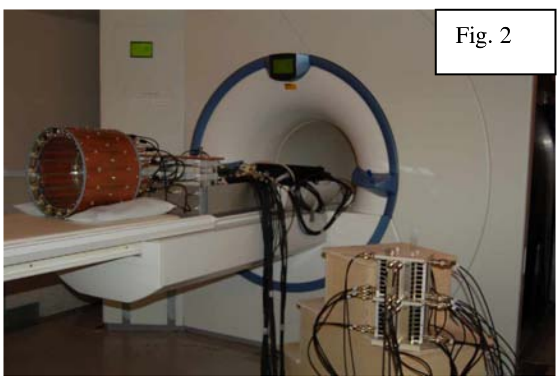
Fig. 2

EXPERIMENTS The above concept was experimentally tested on a Siemens 7T MRI scanner with an additional 16ch transmit/receive VSA and RF interface, see Fig. 2. Each transmit channel has ability to independently adjust phase by precisely cut coaxial cable and adjust attenuation by a 0 to -60dB precision attenuator switch. Each excitation of the 20 wavelet bases in Fig. 1 was implemented by setting the excitation voltage port-distribution to be the FFT of the wavelet mode distribution in Fig. 1. Their corresponding MRI excitation maps are shown in Fig. 3. The transmit voltages for entire mode excitations did not exceed 200V with the presence –5dB cable loss for connecting attenuators outside magnet. To use the MSE method (3) with wavelet bases, a desired square excitation profile was set in Fig. 4 A, its wavelet mode distribution was calculated and shown in Fig. 5 A-B whose corresponding sinusoidal mode distribution is shown in Fig. 5 C-D which has only 16 modes. The voltage port distribution to achieve the desired excitation was derived from FFT of the sinusoidal mode distribution shown in Fig. 5 E-F, which resulted in the regional excitation shown in Fig. 4 B, which is an approximately a tilted square excitation profile.

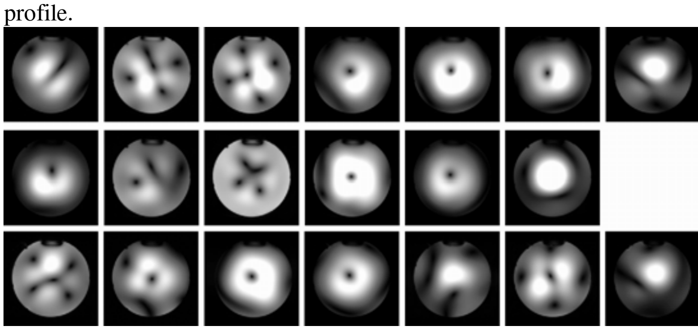
Fig. 3

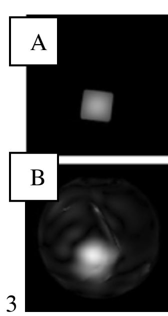

Fig. 4

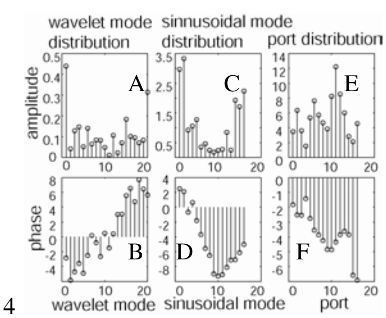

Fig. 5

CONCLUSIONS A wavelet based MSE provides a practical way to achieve regional excitation at 7T which allows us to achieve above-linear SNR increase over the small specified region.

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