# 1D RF Phase Gradient Coil for TRASE RF Imaging

**Q. Deng[1], J. Sharp[1], V. Volotovskyy[2], B. Tomanek[1], and S. King[2]**

[1]Institute for Biodiagnostics (West), National Research Council of Canada, Calgary, AB, Canada, [2]Institute for Biodiagnostics, National Research Council of Canada, Winnipeg, MB, Canada

**Introduction:** The newly proposed TRASE(1) RF imaging method uses RF phase gradients instead of $B_0$ gradients for K space traversal. A RF phase gradient coil can be composed of a cosine component and a sine component creating a combination of two RF field directions normal to each other, and their amplitudes have cosine and sine distribution along the phase gradient direction (2). We have previously shown that the sine component could be achieved by using a Double Maxwell coil (2). Here we report a complete RF phase gradient coil design including a cosine component intended to be used on a 0.2T MRI system with vertical $B_0$ field. The general design aims are: uniformity of $|B_1|$; strength of $B_1$ phase gradient; efficiency; linearity of $B_1$ gradient.

**Methods:** 3D simulations were done using XFDTD7.0 (REMCOM) to optimize the geometry of a Helmholtz type coil to create a cosine field that mated with the sine field of the Double Maxwell coil. The simulation results were stored in 40x40x40cm cube sensors in XFDTD, and converted to image data displayed in our image viewer 'Marevisi' (fig 1). To match the Double Maxwell coil, the dimensions of the Helmholtz coil were selected as 28 x 42 x 28cm. A combined coil was constructed according to the optimized 3D models of Double Maxwell and Helmholtz coils (fig 2). The Double Maxwell and Helmholtz pair was used for transmit only, and a Rx-only solenoid coil was used for acquisition to improve SNR. RF field distribution of each coil component was obtained by using Double Angle method (DMA), with one coil component enabled while another coil component disabled. Power ratio was calculated according to the flip angle distribution of the two coils. A 180-degrees phase shifter was used before the input of the Double Maxwell coil to control the sign of the phase gradient. The RF power from a RF amplifier was divided by an un-equal Wilkinson power splitter and then fed to the two coil components. GE images had been acquired on a 0.2T MRI system from a phantom in two phase states of the 180-degrees phase shifter. The phase gradient strength was computed by subtracting the phases of the two sets of GE images. A 1D TRASE experiment was then performed with four small bottles lined-up along the phase gradient direction.
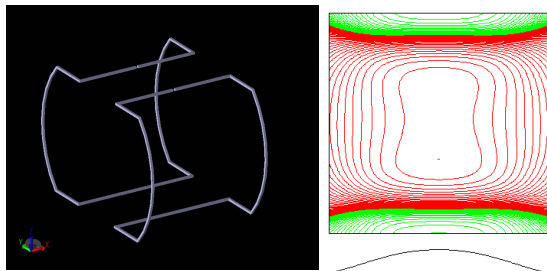


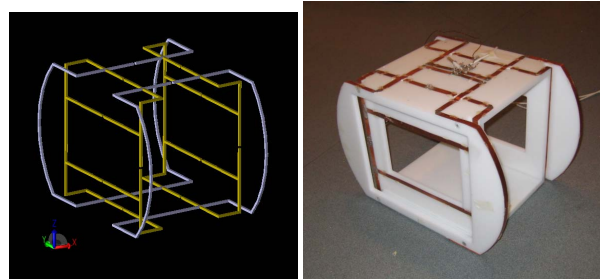**Fig 1.** Helmholtz coil 3D model and its field distribution and center line profile on the center plane



**Fig 2**. 3D model of Double Maxwell/Helmholtz coil and the constructed coil

**Results:** The simulation result showed that the center area of 17 cm diameter of the optimized Helmholtz coil has less than 10% deviation from the cosine waveform, six times larger than that of our previous circular Helmholtz coil. We previously demonstrated that the diameter of the usable volume of the Double Maxwell coil is 16.7cm. The diameter of the usable volume for the combined coil would be at least 16.7cm. The RF field (flip-angle) distribution indicated that the Double Maxwell coil needed much less power than the curved Helmholtz coil. The power ratio of the two coils was calculated out as 4:1. DMA method showed that a good $B_1$ homogeneity of the combined field by the cosine and sine coil components with a 4:1 un-equal Wilkinson RF power splitter (fig 3). The phase gradient distribution was measured (fig 4), and the gradient strength found to be 5 degrees/cm. The 1D TRASE data was acquired successfully from small bottles (doped with $CuSO_4$, different amount of water). After 1D TRASE reconstruction, the profiles of the bottles were obtained (fig 5).
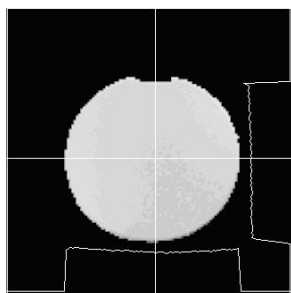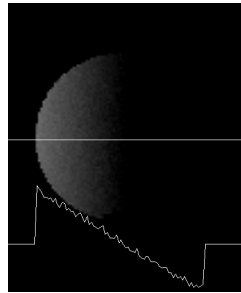


**Fig 3**. $B_1$ field distribution
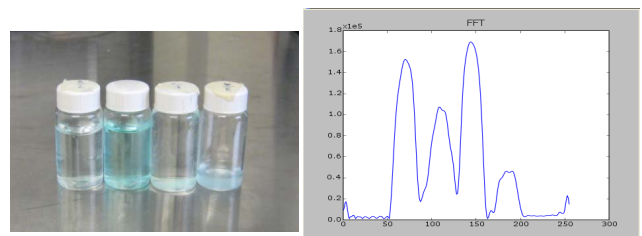


**Fig 4**. Phase distribution



**Fig 5.** 2.5cm diameter bottle phantoms and their 1D TRASE profile

**Conclusion:** A RF phase gradient coil had been designed and constructed successfully for TRASE imaging with a good $B_1$ homogeneity and phase linearity. Its large usable volume enables us to use it for future human knee scans. 1D TRASE experiment was done with the designed coil. Future work includes combining this 1D phase gradient coil with its 90-degrees rotation to make a 2D phase gradient coil, and 2D TRASE experiments.

**Reference:** 1) Sharp-JC & King-SB, Magn. Reson. Med. 63:151–161 (2010); 2) Q.Deng et al, 'A Double Maxwell Sine Field RF Coil for a TRASE RF Phase Gradient Coil Set',ISMRM proceeding 2010; 3) E.K. Insko and L. Bolinger, J. MR. A 103: 82-85 (1993); 5)J.P. Hornak et al. MRM. 6: 158-163 (1988); 6) Y.Wu and Y. Liu, Microwave and Optical Technology Letters, vol. 51, No. 5, May 2009.