# A Linear Phase Volume Excitation Coil

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**Introduction:** Coils with transverse magnetic field profiles having uniform amplitude but linear phase variation across the imaging volume have been demonstrated to be optimal for fidelity of excitation in parallel transmission (1) and are useful for reduced SAR slice selective excitation and for gradient-less imaging (TRASE) (2). Such field profiles have been obtained with twisted birdcage coil designs (2,3). We propose a novel excitation coil design based on a non-resonant microstrip design (4) which achieves very uniform amplitude of transverse magnetic field with linear phase variation along the *z* axis of the coil.

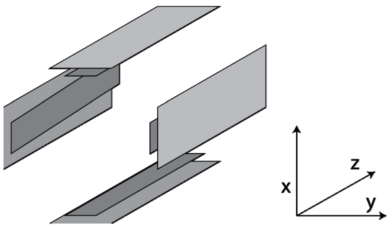


**Figure 1:** Four-element non-resonant microstrip volume coil for excitation. Each stripline is driven at one end and resistively terminated at the other.

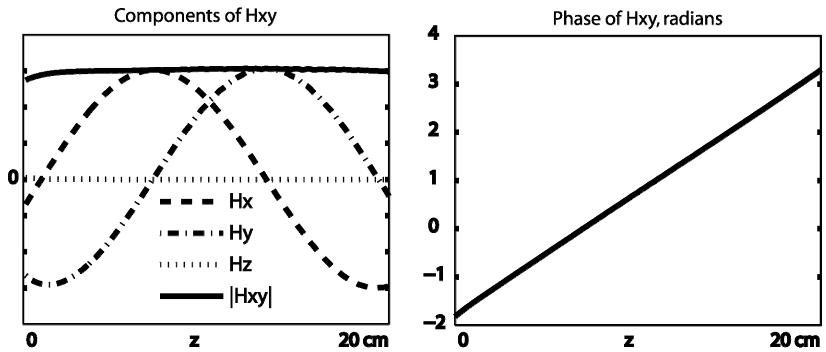


**Figure 2:** Components of magnetic field along the center of the coil volume, over the middle 20 cm of the coil length.

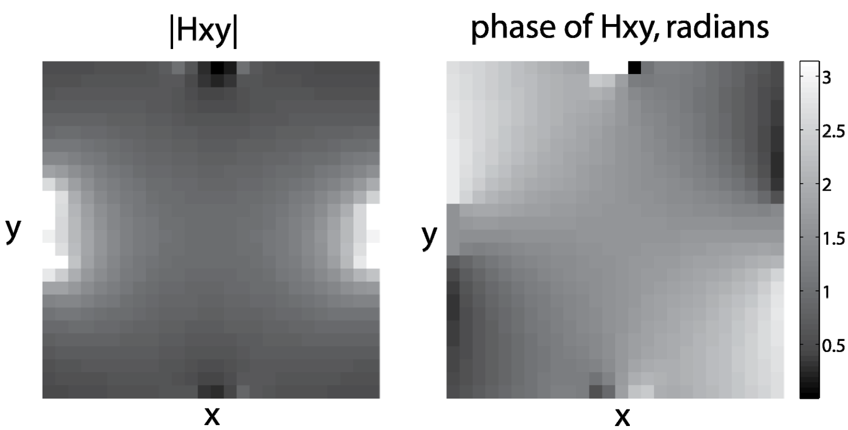


**Figure 3:** Magnitude and phase of transverse magnetic field Hxy at a single instant in time in the *x-y* plane at a point half way down the length of the coil

**Methods:** The coil design is illustrated in Figure 1. The coil consists of four microstrips arranged around a cylindrical volume. Each strip is driven at one end with a sinusoidal input voltage. The four inputs are phase offset by 90 degrees, giving a rotating magnetic field $H_{xy}$ within the imaging volume. The strips are resistively terminated with the characteristic impedance. The EM wave propagates along the length of the striplines without reflection at the end, giving a uniform rotating $H_{xy}$ field within the imaging volume which has linear phase variation along the *z* direction. This coil design was simulated for a coil length of 40 cm at a driving frequency of 1GHz, with perfect conductors and no dielectric between the stripline conductors. Simulation was performed by finite difference time domain (FDTD) methods using the XFDTD software (RemCom, State College, PA).

**Results:** Figure 2 shows the magnetic field at one instant in time along the *z* axis over the inner 20 cm of the coil's 40cm extent in *z*. Linear phase variation of Hxy is seen along the long axis of the coil volume. Figure 3 shows the magnitude and phase of the transverse magnetic field Hxy in a single *x-y* plane halfway along the coil length at a single instant in time. The Hz component (not pictured) is nearly zero.

**Discussion:** The non-resonant stripline coil gives a very uniform transverse magnetic field with linear phase varying in the *z* direction and negligible *z* field. The amount of linear phase depends on the wavelength in the microstrip. For simulation purposes, we have illustrated the case of no dielectric at a driving frequency of 1 GHz, which gives a wavelength of about 30cm. For use as a head excitation coil at 7T, $2\pi$ phase variation could be achieved over a 20cm imaging volume in *z* at 448 MHz by introduction of a dielectric between the strip elements with a dielectric constant of about 11. Shorter wavelengths for operation at lower field strengths or with greater amounts of linear phase variation may be possible with the use of materials with higher dielectric constants, such as microwave ceramics, or with the addition of distributed capacitors.

**References:** **1.** Morrell, *16th Meeting ISMRM*, 2008, p.1081. **2.** Sharp *et al., 16th Meeting ISMRM.* 2008. p 829. **3.** Alsop *et al., Magn Reson Med* 1998;40(1):49-54. **4.** Zhang *et al., 16$^{th}$ Meeting ISMRM, 2008,* p. 435.