A Distributed Capacitor Endcap for Head Coils at 1.5T and 3.0T

C. E. Hayes[1], C. M. Mathis[1]

[1]Radiology, University of Washington, Seattle, WA, United States

Introduction: The location and values of the capacitors on a birdcage resonator determine the distribution and magnitude of the electric fields that are applied to the sample. The lowpass birdcage produces a longitudinal electric field gradient across the sample (Fig 1a). The highpass birdcage produces a transverse electric field gradient (Fig. 1b). An electric field distribution that is uniformly distributed tangentially around the circumference of the sample will minimize the dielectric losses and the detuning effects due to stray capacitance. A hybrid or bandpass birdcage can provide such an electric field distribution (Fig. 1c). When a conventional endcap is added, the RF magnetic field homogeneity is maintained, but the uniformity of the electric field is disrupted by the resulting ground plane located at the top of the head (Fig. 1d).

We have developed an endcap made up of a mesh of uniformly distributed capacitors that retains the electric field uniformity and the magnetic field homogeneity in a shortened hybrid birdcage (Fig. 1e). The endcap consists of an etched double-sided Teflon circuit board containing numerous overlapping capacitor pads. We have implemented the design as a receive-only head coil at 1.5T and as a transmit-receive head coil at 3.0T. This capacitively reactive RF shielding technique may have applications in other coil designs such as TEM resonators.

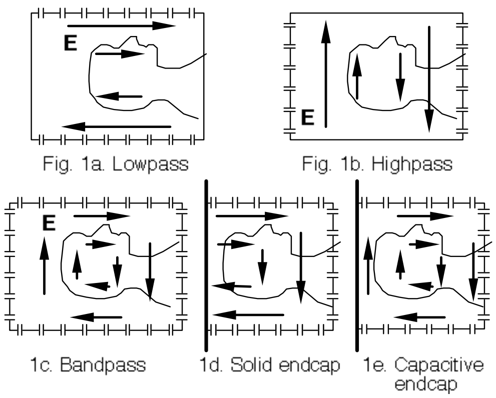

Fig. 1a. Lowpass Fig. 1b. Highpass 1c. Bandpass 1d. Solid endcap 1e. Capacitive endcap

Method: The sixteen-rung birdcage is 20.3 cm long from endcap to endring. The rungs are 2.25 cm diameter cylinders centered on a 30.2 cm diameter circle. The endcap was 40.6 cm in diameter. Figure 2a and 2b show the etched pattern of capacitor pads for a quarter section of the 1.5T endcap on the inside surface and outside surface, respectively. The nine resulting concentric rings of overlapping pads contain, respectively, 4, 8, 12, 16, 24, 32, 48, 64, and 64 etched capacitors. The ring diameters are chosen so that all 272 capacitor are equal. The 3T version of the endcap has 13 rings with a total of 496 capacitors, which reduces its net capacitance by a factor of about four. The rungs at 1.5T were copper foil tubes with three gaps spanned by 68pf chip capacitors. The 3T rungs were etched from Teflon circuit board and contained overlapping pads forming fourteen capacitors in series. Discrete chip capacitors were placed on the sixteen gaps on the endring. The choice of capacitive values resulted in one quarter of the total voltage drop occurring on the endcap, the endring, and the opposing rungs. Each rung of the 1.5T coil was fitted with a low threshold passive blocking circuit.

The coil was driven at four points by tapping across five rings of the endcap. A quadrature hybrid splitter provided the outputs to the horizontal and vertical modes, which were each connected to +90 and –90 degree phase shifters leading to opposite drive points. The characteristic impedance of the phase shifters provided the needed impedance matching.

Results: The hybrid birdcage was dominated by the rung capacitors, i.e., the homogeneous mode was at the low frequency end of the mode spectrum. Field homogeneity measurements near the endcap indicated that the capacitive endcap operated as a RF mirror. When placed in a RF shield equivalent to that in the magnet bore, the unloaded Q was 410 for the 1.5T coil and 650 for the 3.0T coil. With a human head, the loaded Q was 33 for 1.5T and 16 for 3.0T. Compared to the GE Signa head coils at 1.5T and 3.0T, *in vivo* measurements of the SNR within the brain showed that the new coil design had 31% better performance at both frequencies. There was no indication of any gradient induced eddy currents in the highly segmented endcap, rungs, and endring.

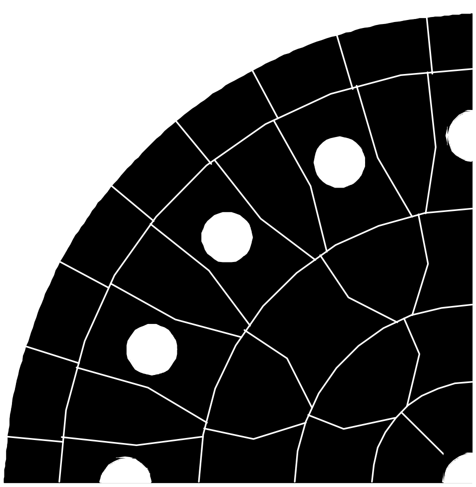

Fig. 2a. Inside Cu foil on one quarter of endcap.

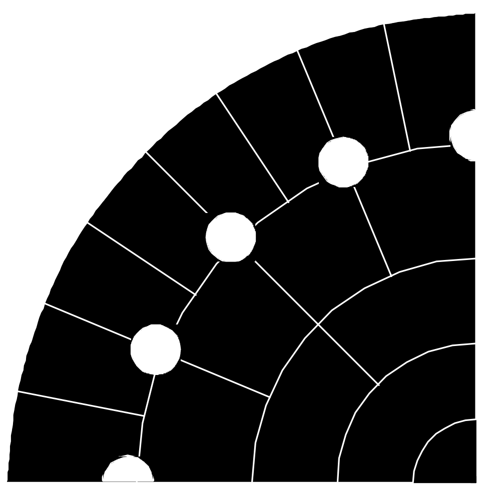

Fig. 2b. Outside Cu foil on one quarter of endcap.