1 Electric conductivity σ estimates

Faraday's law in integral form and Ampere's law in differential form may be combined to yeild an expression for the complex permittivity, κ [12].

$$\frac{\oint_{\partial A} \nabla \times \vec{H} \cdot dl}{\mu\omega^2 \int_A \vec{H} \cdot d\vec{a}} \approx \kappa = \epsilon - i\,\sigma/\omega \qquad \vec{H} = H_x\hat{x} + H_y\hat{y} + H_z\hat{z} \tag{1}$$

The magnetic field applied by the transmit coil is denoted $\vec{H}$, ω is the Larmor frequency, and μ is the permeability. A non-axial plane such as the coronal plane, y = constant, is perferred because the axial component, H_z is not

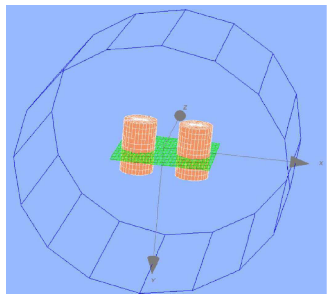

Figure 1: Coronal Imaging Plane [12].

measurable. For reference coronal imaging plane with respect to a right hand coordinate system is shown in Figure 1, In this case (1) may be reduced to an expression for the conductivity, σ.

$$\frac{\oint_{\partial A_{xz}} \left\{ \partial_y \underbrace{H_z}_{=0 \text{ by assumption}} - \partial_z H_y, \partial_x H_y - \partial_y H_x \right\} \cdot dl}{\mu\omega^2 \int_{A_{xz}} H_y \cdot \, dxdz} \approx \kappa = \epsilon - i\,\sigma/\omega \qquad \Rightarrow \qquad \sigma \approx \frac{\oint_{\partial A_{xz}} \partial_x H_y - \partial_y H_x \; ds}{\mu\omega \int_{A_{xz}} H_y \cdot \, dxdz} \tag{2}$$

The integrals yeild a scalar valued average estimate of conduction, $\sigma \in \mathbb{R}$ with the ROI of interest, A.

Paraphasing [12]: "The use of a birdcage-type RF coil is advantageous, i.e., a quadrature body coil (QBC) or corresponding head coil. A birdcage coil allows choosing the coil polarization during transmission and reception. In particular, the structure of the birdcage coil imposes that transmit sensitivity, $H_+ = \frac{H_x + iH_y}{2}$, is substantially larger than receive sensitivity, $H_- = \frac{H_x - iH_y}{2}$. The determination of H_+, is the so-called B1 mapping. A double angle method [11] is appropriate. However, these approaches only describe the determination of the modulus $|H_+|$, from the signal ratio observed at the two flip angles θ_i .

$$|H_+| = \frac{\cos^{-1}\left(\frac{1}{2\,r}\right)}{\omega t} \qquad r = \frac{1}{2\ \cos\theta_1} = \frac{\sin\theta_1}{\sin\theta_2} \qquad \theta_2 = 2\,\theta_1 \tag{3}$$

The use of a switched birdcage coil allows also the estimation of the B1 phase."

References

[11] EK Insko and L Bolinger. Mapping of the radiofrequency field. *Journal of Magnetic Resonance, Series A*, 103(1):82–85, 1993.

[12] Ulrich Katscher, Tobias Voigt, Christian Findeklee, Peter Vernickel, Kay Nehrke, and O Dossel. Determination of electric conductivity and local sar via b1 mapping. *Medical Imaging, IEEE Transactions on*, 28(9):1365–1374, 2009.