On the Effect of Antenna Illumination Patterns on the Accuracy and Resolution of Microwave Tomography

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The quantitative accuracy and resolution achievable from microwave tomography (MWT) are governed by several factors, such as the signal-to-noise ratio of the measured data, the number of antenna elements, and the data calibration technique (P. Mojabi et. al., *ANTEM*, 2012). In this paper, we investigate the effect of antenna illumination patterns on the achievable quantitative accuracy and resolution of MWT. Different antenna elements, such as monopole and Vivaldi antennas, have been used in MWT systems; however, to the best of our knowledge, the effect of antenna illumination patterns on the accuracy and the resolution of the final dielectric profile image is not currently known.

From the mathematical formulation of the MWT problem, it can be seen that the antenna illumination pattern (incident field distribution within the imaging domain) contributes to the induced total field within the object being imaged. Noting that the induced total field within the object partially determines the amount of information that can be obtained from the object being imaged, it can be concluded that the antenna illumination pattern contributes to the quantitative accuracy and resolution achievable from MWT.

In the first part of this paper, we show that the utilized antenna illumination pattern affects the aforementioned accuracy and resolution of MWT. To this end, we synthetically collect MWT *measured* data sets using different antenna illumination patterns, starting from an omnidirectional pattern, then progressively employing more directive patterns. We will then invert these data sets using different inversion algorithms such as the multiplicative regularized Gauss-Newton inversion (P. Mojabi and J. LoVetri, *IEEE Antennas Wireless Propag. Lett.*, 2009) and contrast source inversion (A. Abubakar et. al., *IEEE Trans. Microw. Theory Tech.*, 2002) methods. For all of the objects that we have successively illuminated by at least 8 antenna elements, directive patterns have provided either more accurate images or images of at least the same level of accuracy as those obtained by an omnidirectional pattern.

In the second part of this paper, we investigate why the more directive illumination patterns have provided these better reconstruction results as compared to the omnidirectional pattern for our numerical trials. To this end, we discuss the singular value dynamics of the Jacobian (sensitivity) matrix, and show that the directive antenna illumination patterns result in better singular value dynamics as compared to the omnidirectional pattern. Thus, it is speculated that for the same signal-to-noise ratio of the measured data, the more directive patterns have extracted more information from the object being imaged.