Antenna Incident Field Distribution: Its Effect on the Achievable Image Accuracy from Microwave Tomography

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In microwave tomography (MWT), the object being imaged is successively illuminated by a set of antennas located external to the object. The scattered data emanating from the object is measured and will then be used by an appropriate imaging algorithm to find the object’s dielectric profile. Broadly speaking, the image accuracy achievable from MWT depends on two factors: (1) how much the information content of the measured data is, and (2) how well the utilized imaging algorithm can extract and use this information content.

It is known that the choice of the utilized antenna element in a given MWT system affects the aforementioned second factor. This is due to the fact that some antennas, e.g., monopole antennas, can be modeled more easily within an imaging algorithm. Therefore, the so-called modeling error will be reduced if such simple antennas are used in the MWT system. Having less modeling error in the utilized imaging algorithm will thus result in enhanced image accuracy.

In this work, we show that the choice of the antenna can also have an effect the first factor; i.e., the information content of the measured data. (This work has also been presented in the 2013 IEEE APS-URSI by the author and his advisor.) To show this, a numerical model for the antenna incident field distribution is adopted. This model has a parameter that controls the focusing level of the antenna incident field distribution. It should be noted that this focusing level does not necessarily represent the directivity of the antenna. This is due to the fact that the directivity is a far-field quantity; however, in most MWT systems, antennas operate in their near-field zone. It will be shown that by changing this focusing parameter, reconstruction results with different image accuracy levels will be obtained.

It will be further shown that the use of a more focused near-field distribution results in either enhanced image accuracy (especially when the number of utilized antennas is small), or almost the same accuracy as compared to a less focused distribution (e.g., an omnidirectional distribution). It is speculated that this is due to the fact that a more focused near-field distribution provides enhanced singular value dynamics for the associated mathematical problem.

Finally, a preliminary design for a small multi-band antenna with some near-field focusing abilities will be presented. After optimization of this antenna (to be performed later), it will be fabricated and tested in the planar near-field antenna range in the Antenna Lab. Later, it will be used for imaging purposes at the Electromagnetic Imaging Lab.

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