URSI GASS 2021, Rome, Italy, 28 August - 4 September 2021

Application of Electrically Reconfigurable Plates in Microwave Imaging within a Metallic Enclosure

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One of the techniques to enhance the performance of imaging systems is to increase the amount of independent measured data that is collected when interrogating the object-of-interest (OI) being imaged. For each illuminating field that is utilized to interrogate the OI one collects data at several locations around the OI. The collected data over all the illuminating fields is the data that will be inverted to create an image of the complex-valued permittivity of the OI. The common approach to increasing the amount of independent data is to increase the total number of transmitter/receiver pairs. However, the amount of data that can be collected using this common approach is limited by the resulting increase in the complexity of the system: there is a limited amount of space available around the OI to fix co-resident antennas. Even if a large number of antennas was to be used, space permitting, the required computational resources to include numerical models of the co-resident antennas within the inversion model would be too high. Scanning systems that use a single transmitter/receiver configuration suffer from inaccuracies due to the motion of the antennas. In [1], a novel technique where ther motion of the conductive chamber is used to create a diverse interrogating field was introduced. This allowed a reduced number of transmitter receiver pairs to be used, albeit, with the disadvantage of requiring the chamber itself to rotate. In [2], the idea was extended to the use of dynamic boundaries that could be turned on and off electronically within the chamber. These dynamic boundaries create the required diverse interrogating fields. In [2], the dynamic boundaries consisted of thin-wire-based field perturbing elements.

The research reported herein builds on these two previous investigations by fitting a cylindrical metallic enclosure having flat-faceted walls with a set of electrically reconfigurable plates (or fins) that project into the chamber. Transmit and receive antennas are placed on the walls of the chamber and for each transmitter the interrogating field can be changed by turning one or more of the reconfigurable plates on or off. This allows us to reduce the number of transmit antennas that are used. Our current system consists of an octogonally shaped cylindrical chamber with 24 transmitter and receiver antennas. The size of the metallic chamber on the order of a few wavelengths and therefore constitutes a quasi-resonant chamber (we utilize an open top adding some loss to the chamber). The plates include a pattern of segmented PCB traces with multiple diodes connecting the trace segments. To reduce the computational resources required to model these reconfigurable plates, the design criteria is to choose a pattern of the segmented PCB traces that minimally perturb the field within the chamber when the diodes are “OFF” (*i.e.*, in revers-biased mode). This allows us to remove the plates from the numerical model in the “OFF” mode with small effects on the accuracy. In the “ON” mode, the plates are modelled as PEC surfaces. To evaluate the performance of the proposed approach, multiple DUTs are imaged in the chamber for different configurations and combinations of the electrically reconfigurable plates and the results will be presented at the conference.

References

[1] P. Mojabi and J. LoVetri, “A novel microwave tomography system using a rotatable conductive enclosure," *IEEE transactions on antennas and propagation*, vol. 59, no. 5, pp. 1597-1605, 2011.

[2] M. Asefi and J. LoVetri, “Use of field-perturbing elements to increase nonredundant data for microwave imaging systems," *IEEE Transactions on Microwave Theory and Techniques*, vol. 65, no. 9, pp. 3172-3179, 2017.