Dielectric Properties of Honey Bee Body Tissue for Insect Tracking Applications

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Developing applications for insect tracking systems that are used to study flying insect behavior and migration is essential for our future. In these applications, Radar Cross Section (RCS) predictions depend on the surface profile and relative permittivity of these insects. In order to obtain an accurate prediction of RCS of the honey bee body tissue, measuring its dielectric properties is vital. Therefore, we investigated the dielectric properties of the honey bee tissue to study its interaction with electromagnetic fields.

The dielectric measurements were performed using an X-band system to determine relative permittivity of the honey bee body tissue at a frequency range from 8 GHz to 12 GHz at room temperature for a rectangular waveguide that is packed with honey bees. Then, both transmission and reflection parameters were measured to determine the dielectric properties using a vector network analyzer (VNA). To eliminate the effect of air gaps between the samples and the waveguide on dielectric measurements, the Landau & Lifshitz and Looyenga dielectric mixture equations were used to provide effective relative permittivity of the solid honey bee tissue. Prior to that, the volume of the honey bee group was estimated using an acetone graduated cylinder displacement technique. The relative permittivity found of the honey bee body tissue decreased from 11.64 to 10.32 as the frequency increased from 8.2 to 12.4 GHz, respectively. Furthermore, the loss tangent was found to increase from 0.23 to 0.36 for the same frequency range. Using these measurements, the RCS can be easily simulated and predicted using commercial FEKO antenna modeling software. Also, the obtained results show that the honey bee body tissue has a potential to be used as dielectric substrate for microstrip patch antennas in harmonic radar systems.