Adaptive Tuning in Terahertz Metamaterials using Swarm Intelligence

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Abstract Terahertz imaging is growing at the rapid pace and finds application in fields such as astronomy, material characterization, tumor detection, security and detection of concealed items, etc. Advances in this wide range of applications are hindered by the lack of natural dielectrics in the terahertz range of frequencies. This challenge is combated by the usage of artificially engineered material called metamaterial – electromagnetic structures obtained by patterning metal on a dielectric. Metamaterial based absorbers are used to improve the performance of detectors in terahertz imaging. These EM structures are often resonant and their application is restricted to narrow bands. However, the applications in terahertz require reception of signals over wide band of frequencies. This issue can be sorted out by designing active metamaterials whose resonant frequency can be tuned.

Mathematical formulation for the design of metamaterial based absorbers is cumbersome. While equations for the design of the metamaterial itself may be found, the presence of additional dielectrics in the construction of absorbers shift the resonant frequency. This brings about the need for the use of computational optimization tools in order to arrive at the best structural parameters. In addition, the lack of mathematical formulation necessitates the integration of these optimization tools with EM simulators in order to achieve optimization through iterative simulations. In this paper, a swarm intelligence based algorithm viz. particle swarm optimization (PSO) is used to develop a computational engine for the design of an active terahertz metamaterial absorber. The computational engine arrives at the optimum solution by simulating designs in a commercially available EM simulator.

In this paper, a circular split ring resonator (CSRR) is used as the metamaterial unit cell for the absorber whose structural parameters are obtained using the PSO. It has been observed that the resonant frequency of the absorber can be varied by rotating the inner ring of each CSRR. Further, the developed swarm intelligence based computational engine is used to find the optimum rotation angles of the inner rings of each CSRR for a range of frequencies. Therefore, a database of rotation angles for a range of frequencies is obtained. This database can be used for the rapid, adaptive tuning of the absorber array in practical applications.

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