The Impact of Passive and Active Metamaterial Constructs on Electrically Small Radiating and Scattering Systems

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Abstract-The impact of introducing active elements into metamaterial constructs for enhancing the performance of electrically small radiating systems at UHF and VHF frequencies and highly subwavelength scattering systems at optical frequencies will be presented.

It has been demonstrated that metamaterial-inspired electrically small antennas (ESAs) can be designed to achieve very high overall efficiencies [1]. Their further miniaturization at VHF and UHF frequencies has been enabled by introducing lumped elements as was done to achieve the highly subwavelength ENG, MNG, and DNG unit cells reported in [2]. We have been investigating how the inclusion of active elements into electric (resonant) and magnetic (anti-resonant) ESAs will impact their performance. It will be shown that the inclusion of non-Foster elements internally in a metamaterial-inspired electric or magnetic ESA can lead to significant increases in their bandwidths while maintaining their overall efficiencies.

Current research in optical metamaterials has demonstrated that the inclusion of lossless plasmonic materials to achieve a negative permittivity in the spherical shell of a coated nano-sized particle (CNP) can lead to novel optical properties such as resonant scattering as well as transparency or invisibility. However, in practice, plasmonic materials have rather high losses at optical frequencies. It has been reported [3] that with the introduction of active materials into the CNPs, the intrinsic absorption in the plasmonic shell can be overcome and interesting optical properties can be observed in their scattering and absorption cross-sections. In particular, these active CNPS can be designed to produce optical amplification, i.e., to achieve highly subwavelength lasers. It will be shown that these CNP lasers can have significant impacts on optical nano-antenna, sensor, and amplifying media applications.

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