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(57) Abstract :
In this work, gain enhancement of a rectangular microstrip patch antenna operating at 28 GHz for 5G millimeter-wave applications is presented using a phase-engineered graded-index metasurface lens. Metamaterial unit cells are designed and radially arranged to realize the desired phase distribution and to study transmission characteristics. The proposed lens structure has a focal length-to-diameter ratio of 0.38. Due to the electromagnetic focusing effect of the metasurface placed along the radiation direction, a gain improvement of 2.32 dBi is achieved. The planar metasurface lens is compact and fabrication-friendly with dimensions of 30 mm × 30 mm, offering advantages over conventional bulky three-dimensional lenses. The metasurface-integrated antenna exhibits a peak gain of about 8.33 dBi and radiation efficiency above 98% over the operating band of 27.5–29.1 GHz. Comparative analysis of the conventional patch antenna and the metasurface Luneburg-lens-loaded antenna is carried out through theoretical evaluation and experimental validation. Full-wave finite-element simulations show close agreement with measured results, confirming the effectiveness of the proposed approach for enhanced-gain 5G millimeter-wave patch antennas.

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