Fully-Metallic Leaky-Wave Antenna with Low Dispersion for 60 GHz Point-to-Point Communications

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Recently, especially in the millimeter band, leaky-wave antennas (LWAs) have attracted interest for point-to-point or point-to-multipoint wireless and satellite communication systems benefiting from their low profiles and simple feeding networks (A. A. Oliner D. R. Jackson, "Leaky-wave antennas" in Antenna Engineering Handbook New York: McGraw-Hill 2007). However, their application in such systems has been limited due to their beam squinting with frequency which leads to gain losses at the desired radiation direction. Many efforts have been made trying to overcome this limitation but the reported solutions unavoidably suffer from either gain losses and broaden beams, prohibitive complexity, or low efficiency. In order to overcome these drawbacks, a novel general technique to reduce the beam squint in any type of LWA was recently proposed based on a complementary-dispersive prism coupling. This techique was implemented in pin-type groove-gap waveguide (GGW) technology at X-band (L. Wang, J. L. Gomez-Tornero, E. Rajo-Iglesias, and O. Quevedo-Teruel, "Low-dispersive leaky-wave antenna integrated in groove gap waveguide technology," IEEE Trans. Antennas Propag., vol. 66, no. 11, pp. 5727-5736, Nov 2018).

In this work, a novel low-dispersive LWA operating at 60 GHz is proposed utilizing a dispersive prism. The antenna is implemented in a full-holey metallic structure, resulting in a more cost-effective and easier manufacturing process compared to previous pin-based structures. The operation of the leaky waveguide is based on holey GGW technology, where glide-symmetric holes are drilled in both lateral walls (O. Quevedo-Teruel, M. Ebrahimpouri, and M. N. M. Kehn,"Ultrawideband metasurface lensesbased on off-shifted opposite layers," IEEE Antennas Wireless Propag. Lett., vol. 15, pp. 484-487, Dec 2016). While one of them acts as a perfect electric conductor (PEC) wall loaded with electromagnetic bandgap (EBG) holes to prevent leakage, the other performs as a partially reflective wall where the leaky-wave radiation occurs. By tailoring the hole diameters and the waveguide width, the leakage rate α and propagation constant β of the leaky TE_{10} mode in the waveguide are controlled so low sidelobe levels (SLLs) are obtained. To mitigate the beam squint due to the dispersive nature of LWAs, a complementary dispersive prism consisting of holey parallel plates is coupled to the LWA radiation aperture to compensate such dispersion. Additionally, when the prism possesses a glide symmetry and operates at the second propagating mode, much fewer holes are required while maintaining a similar performance, which even further decreases the fabrication costs. Two prototypes are demonstrated and experimentally validated with a central frequency of 60 GHz and a gain of 18 dB. A 10% frequency bandwidth for the 3 dB realized gain at $\phi = 45°$ is achieved, with a beam angle variation less than $\pm 1.5°$.