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Designs of Automotive High-Gain TM_{05}-Mode Patch Array Antennas

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Abstract

This work presents the design and implementation of three TM_{05}-mode patch array antennas for automotive radar applications, featuring high gain, low sidelobe level (SLL), and enhanced bandwidth. To improve radiation performance, patches in TM_{05} mode are employed with surface-etched slots to suppress reverse currents, thereby increasing gain and reducing SLLs. Antenna I is a 79-GHz 2\times 8 TM_{05}-mode patch array antenna fed by a substrate-integrated waveguide (SIW) network with differential excitation to minimize cross-polarization. An SIW-based excitation design highlighting Taylor distribution is applied to further suppress sidelobes. Measured results show a –10 dB impedance bandwidth of 77.92-79.15 GHz (1.6%), a peak gain of 18.2 dBi, and a SLL of –19.1 dB in H-plane. The cross-polarization level is reduced to nearly 30 dB lower than the co-polarization level. Antenna II is a 77-GHz staggered series-fed six-element TM05-mode patch array designed for

compact integration. An in-phase excitation scheme with an array spacing of $3\lambda_g/2$ is proposed. This antenna achieves a measured bandwidth of 73.76–78.44 GHz (6.1%) and a high gain of 17.5 dBi with only six elements. Antenna III further introduces parasitic strips alongside each patch from Antenna II to generate additional resonances and to enhance bandwidth. Measured results exhibit a bandwidth of 72.64–80.75 GHz (10.57%) and a peak gain of 17.8 dBi, representing an increase of 4.47% in bandwidth compared to Antenna II. In summary, Antenna I achieves high gain, low SLL, and low cross-polarization with higher complexity, while Antennas II/III simplify design yet deliver high gain and wide bandwidth, offering promising solutions for automotive radars. © 2013 IEEE.

Author keywords

Automotive antenna; bandwidth enhancement; differential feeding; high-gain antenna; higher-order mode patch; sidelobe level suppression; staggered series feeding; TM_{05}-mode patch antenna

Indexed keywords

Engineering controlled terms

Antenna arrays; Antenna feeders; Automotive radar; Bandwidth; Directional patterns (antenna); Electric impedance; Microwave antennas; Polarization; Radar antennas; Slot antennas

Engineering uncontrolled terms

Automotive antennas; Bandwidth enhancement; Differential feeding; High gain antennas; High order mode; High-order mode patch; Higher-order-mode; Sidelobe level suppressions; Staggered series feeding; Tm05-mode patch antenna

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Microstrip antennas

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