Designs of Automotive High-Gain TM05-Mode Patch Array Antennas

By Kuo, TW (Kuo, Ting-Wei) [1] ; Chen, YLZ (Zhu Chen, Yu-Liang) [1] ; Li, ES (Li, Eric S.) [2] ; Jin, HY (Jin, Huayan) [3] ; Chen, DX (Chen, Dongxu) [4] ; Malek, NFA (Farihah Abdul Malek, Norun) [5] ; Chin, KS (Chin, Kuo-Sheng) [1]

Are you this author?

View Web of Science ResearcherID and ORCID (provided by Clarivate)

Source IEEE ACCESS

View Journal Impact

Volume: 13 Page: 184875-184888

DOI: 10.1109/ACCESS.2025.3624458

Published 2025

Indexed 2025-11-13

Document Type Article

Abstract This work presents the design and implementation of three TM05-mode patch array antennas for automotive radar

applications, featuring high gain, low sidelobe level (SLL), and enhanced bandwidth. To improve radiation performance, patches in TM05 mode are employed with surface-etched slots to suppress reverse currents, thereby increasing gain and reducing SLLs. Antenna I is a 79-GHz 2 x 8 TM05-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.

Keywords

Author Keywords: Antenna arrays; Bandwidth; Radar antennas; Automotive engineering; Microstrip antenna arrays; Gain; Antenna radiation patterns; Antenna measurements; Substrates; Patch antennas; Automotive antenna; bandwidth enhancement; differential feeding; high-gain antenna; higher-order mode patch; sidelobe level suppression; staggered series feeding; TM05-mode patch antenna

Keywords Plus: 79 GHZ; PERFORMANCE ENHANCEMENT; MICROSTRIP ANTENNA; MODE

Author Information

Corresponding Address: Chin, Kuo-Sheng (corresponding author)

Chang Gung Univ, Dept Elect Engn, Taoyuan 33302, Taiwan

E-mail Addresses :

kschin@mail.cgu.edu.tw

Addresses :