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Metamaterial-Inspired Low-Profile Wideband Microstrip Patch Antenna with Defected Ground Structure for Smart Transportation Systems (STS)

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Abstract:

High-gain microstrip antennas, inspired by metamaterial, have emerged as a promising solution to meet the stringent requirements of vehicular communication. By integrating metamaterial-inspired designs, microstrip antennas can achieve the high directionality and reliability needed for vehicle-to-vehicle (V2V) and vehicle-toeverything (V2X) communications. In view with the stringent requirements in the field of vehicular communication a metamaterial-inspired square-gap defected ground structure based low profile microstrip antenna is proposed. The antenna has overall size of 26×23×1.6 mm^3. The proposed antenna exhibits wideband performance which covers various commercial communication applications, including Wi-Fi, WLAN, 5G and satellite communications, within the frequency range of 3.5 GHz to 6.8 GHz. The metamaterial properties of the proposed design ensure excellent impedance characteristics, achieving a peak realized gain of 13.6 dBi and a

maximum radiation efficiency of 94.95% and fractional bandwidth of 56.9%. This indicates that the antenna operates over a wide frequency range, making it suitable for wideband applications. Low cost FR4 is used as a substrate material. Fundamental parameters of the proposed antenna are optimized through the Annoys HFSS™ simulation software and then compared it with the measured results.

Keywords: Defected Ground Structure, Metamaterial Design, Wideband Characteristics, Planar Antenna, HFSS™.

I. Introduction:

The rapid advancements in vehicular communication system have revolutionized the transportation industry by enabling real-time data exchange between vehicles and infrastructure. These systems play a crucial role in ensuring safer, more efficient, and autonomous driving experiences. However, the efficiency and reliability of such systems depend significantly on the performance of the antennas, which serve as the primary communication interface. Modern wireless communication systems exhibit a strong preference for antennas capable of wide-band operations. Key factors to consider when designing an antenna include fundamental parameters such as gain, bandwidth, and return loss. Enhancing these antenna characteristics is a significant demand in the rapidly expanding wireless industry. Microstrip antennas become primary choices over other types, because of their compactness, conformal nature and ease of fabrication. Furthermore, the ability of microstrip patch antennas to operate through a wide range of bands makes them the primary choice for numerous wireless commercial communication systems worldwide [1].