

# Design of an Extremely Low-Profile Inverted F Antenna for Vehicular Communication

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**ABSTRACT:** There are various types of antenna that can be used for communication systems. This paper presents the design of an extremely low-profile Inverted F antenna for vehicular communication. The proposed model receives the GPS frequency range from 1.176 GHz to 1.575 GHz placed in vehicles. The antenna is designed on the FR4 substrate of dielectric constant of 4.4. The antenna parameters such as Frequency, Return loss, Impedance, VSWR and Radiation pattern is simulated by using HFSS software package.

**KEYWORDS:** Inverted F Antenna (IFA), FR4 substrate, Global Positioning System (GPS), Vehicular Communication.

## I. INTRODUCTION

Inverted F Antennas are widely used in wireless communication systems especially in vehicles and mobile handsets due to light weight, low profile and easy to manufacture. It consists of a rectangular planar element located above a ground plane, a short circuiting plate or pin, and a feeding mechanism for the planar element. The Inverted F antenna is a variant of the monopole where the top section has been folded down so as to be parallel with the ground plane. This is done to reduce the height of the antenna, while maintaining a resonant trace length. This parallel section introduces capacitance to the input impedance of the antenna, which is compensated by implementing a short-circuit stub. The ground plane of the antenna plays a significant role in its operation. Excitation of currents in the printed IFA causes excitation of currents in the ground plane. Surface mounted antennas in cars, trains, and aircrafts etc., needs to be smaller in size so that it consumes less fuel. The proposed antenna used FR-4 substrate for miniaturization of elements.

The Global Positioning System (GPS) is a space-based satellite navigation system that provides location and time information in all weather conditions, anywhere on or near the Earth where there is an unobstructed line of sight to four or more GPS satellites. The system provides critical capabilities to military, civil and commercial users around the world. GPS has become a widely deployed and used for scientific uses, tracking, and surveillance. GPS's accurate time facilitates everyday activities such as banking, mobile phone operations, and even the control of power grids by allowing well synchronized hand-off switching. GPS receiver calculates the position by precisely timing the signals sent by GPS satellites high above the Earth. In general, GPS receivers are composed of an antenna, tuned to the frequencies transmitted by the satellites, receiver-processors, and a highly stable clock.

The industry requires a low cost and high performance antenna that can be placed in the roof of the vehicle. The Global positioning system (GPS) is the most popular member of global satellite navigation systems (GNSS). The integration of L5 1.176.45 GHz frequency band with L1 (1.575 GHz), L2 (1.227 GHz), L3 (1.381.05 GHz) and L4 (1.379.913 GHz) frequency bands has introduced the multi band GPS operation that will improve the robustness of this service and techniques for high accuracy positioning.

Availability of limited space on GPS receivers plays a major challenge for the design. Embedding multiple antennas in a GNSS receiver to cover all five frequency bands gives problem of mutual coupling that degrades the performance of system design. In order to overcome this problem, a single antenna is designed that can cover multiple GNSS bands effectively and efficiently.

## II. ANTENNA DESIGN

The inverted F antenna appears to be a wire antenna. The geometry of the proposed antenna is shown in the figure 1. The feed is placed from the ground plane to the upper arm of the IFA. The upper arm of the IFA has a length that is roughly a quarter of a wavelength. To the left of the feed the upper arm is shorted to the ground plane.

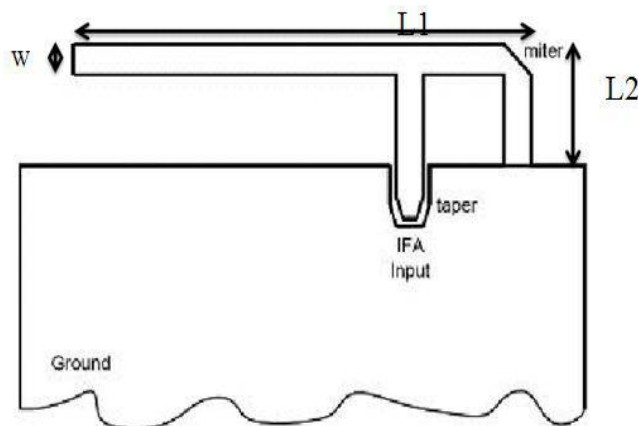


Figure 1: Geometry of the proposed IFA

Parameters	Values(mm)
L1	25.4
L2	11.2
W	2

Table 1: Dimensions of the proposed IFA

This single IFA achieves the linear polarization with the above mentioned parametric values. The total length  $L1+L2+W$  of the antenna is equal to the quarter wavelength of IFA has been used to achieve the circular polarization. In order to achieve circular polarization, an array of inverted F antenna is placed on other end of the substrate. By placing antenna 1 and antenna 2 at each end, the mutual coupling between the successive antennas is avoided. Crossed dipole antenna is used at the edge of this model to achieve circular polarization (RHCP and LHCP).

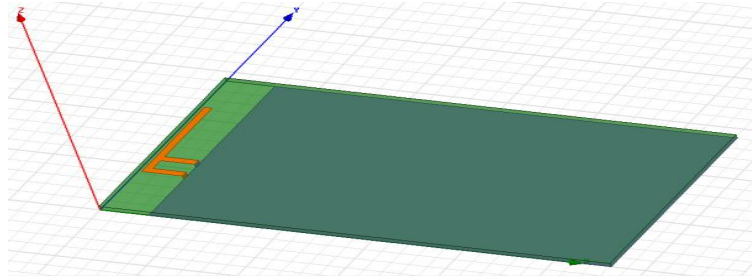


Figure 2: Single IFA design in HFSS

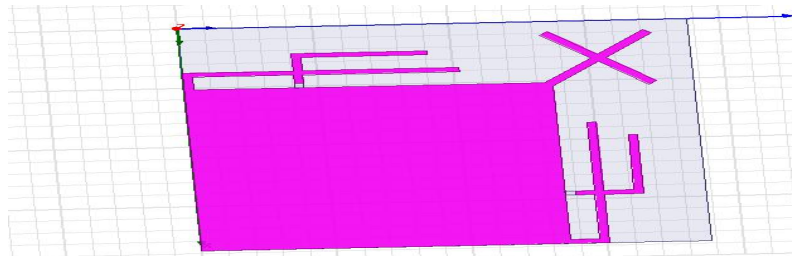


Figure 3: Antenna array design in HFSS 2.5.

### III. SIMULATION RESULTS

The simulated results for single IFA is shown from figures 4 to 7 and the figures from 8 to 12 shows the radiation pattern for all the GPS frequencies used in vehicular communication. Figure 13 shows the VSWR for antenna 1 and 2. Figure 14 shows axial ratio for all the GPS frequency.

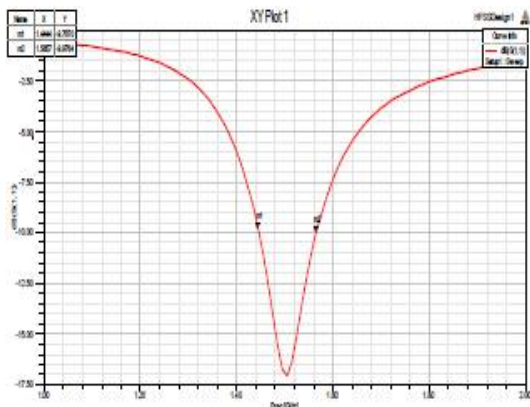


Figure 4: Frequency Vs return loss

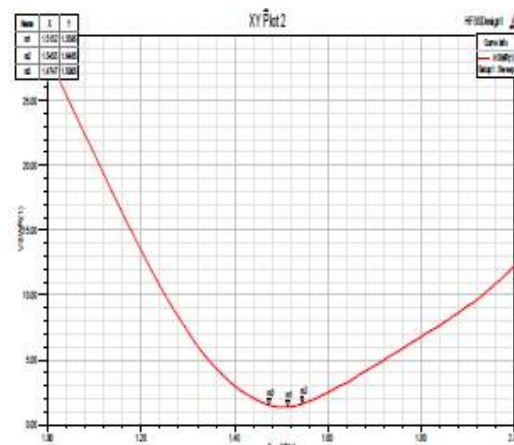


Figure 5: Frequency Vs VSWR

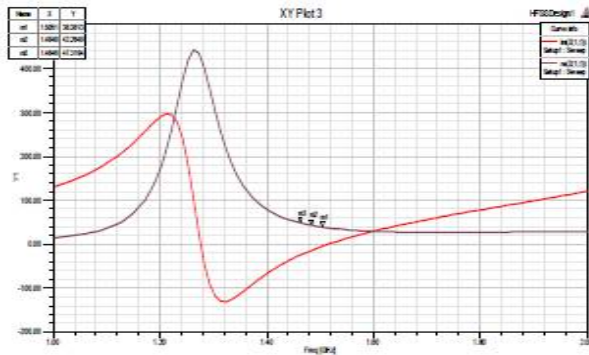


Figure 6: Impedance plot

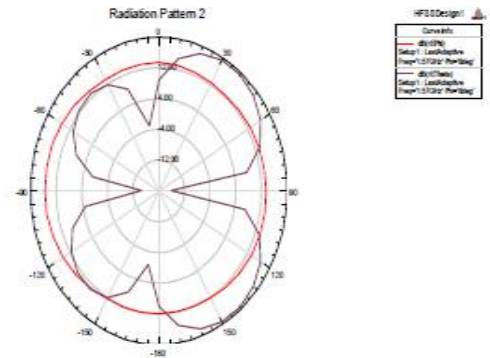


Figure 7: Radiation pattern for single IFA

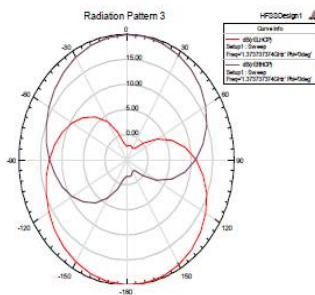


Figure 8: Radiation pattern at 1.37 GHz

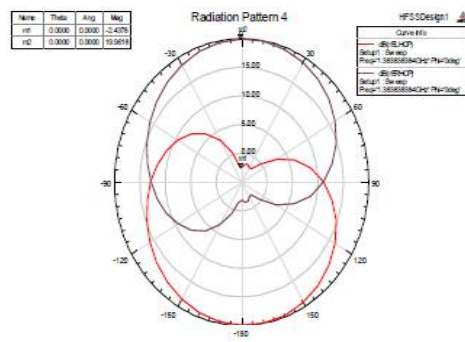


Figure 9: Radiation pattern at 1.38 GHz

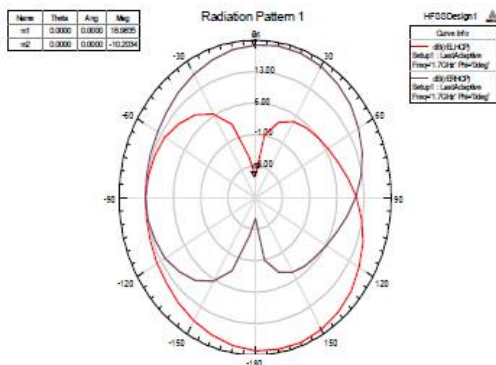


Figure 10: Radiation pattern at 1.7 GHz

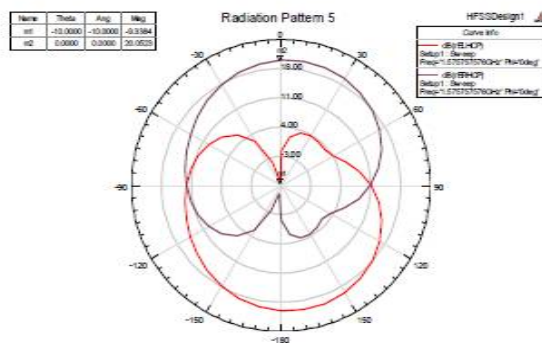


Figure 11: Radiation pattern at 1.57 GHz

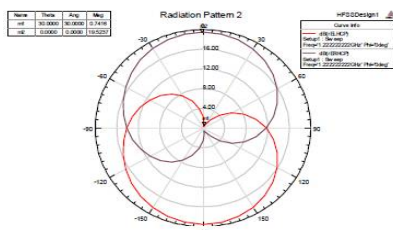


Figure 12: Radiation pattern at 1.22 GHz

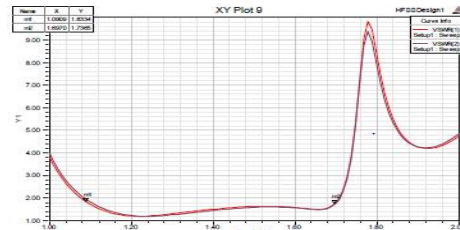


Figure 13: VSWR plot for antenna 1 and antenna 2

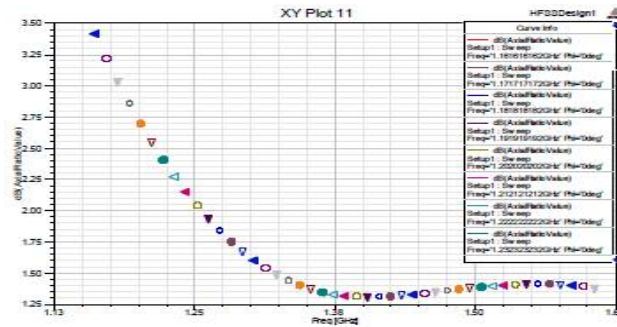


Figure 14: Axial ratio for all frequency

#### IV. CONCLUSION

An extremely low-profile inverted F antenna is designed by HFSS for vehicular communication. The simulated results for single inverted F antenna and the array antenna array is shown. The simulated results shows that antenna array is suitable for receiving all the operating frequency of GPS. The proposed antenna produces a stable radiation pattern.

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