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# Dual-band Inverted-F Antenna for Military and Intelligent Transportation System Applications

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## ABSTRACT

A single feed dual-band modified inverted-F antenna (IFA) operating at 4.4-5.0 GHz and 5.850-5.925 GHz bands is proposed. The antenna is designed and analysed by the method of moments (MoM's) in the Numerical Electromagnetic Code (NEC). The full wave numerical analysis shows the ability of the proposed antenna to operate in the above mentioned bands in terms of return loss, bandwidth, efficiency and gain. The antenna is designed for multi-serving purposes such as military and the intelligent transportation systems (ITS) applications. The antenna provides a pick gain of 6.63 dBi and 1.61 dBi in the 4.4-5.0 GHz and 5.850-5.925 GHz bands, respectively.

**Keywords:** Inverted F-antenna (IFA), modified IFA, ITS technology, military band

## 1 INTRODUCTION

IN recent years, inverted-F antennas (IFAs) are widely used for various purposes including communications, medical, military, scientific, commercial and industrial applications. Intelligent transport systems (ITS) are a group of new technologies designed to improve road safety and support the more efficient use of transport infrastructure. Dedicated short range communications (DSRCs) [1] is an emerging wireless ITS technology developed to transmit safety and traffic information over short distances. DSRC enables data communications between vehicles. It can also be used for communications between vehicles and roadside infrastructure to support traffic coordination and broadcast of safety information [2]. It is important to have high performance antenna for this applications. The antenna will improve transmission and reception, reduce power consumption, and increase marketability of the ITS technology. The 5.9 GHz band (5.850-5.925 GHz) is used for a variety of DSRC such as traffic light control, traffic monitoring, travelers' alerts, automatic toll collection, traffic congestion detection, emergency vehicle signal preemption of traffic lights, and electronic inspection of moving trucks through data transmissions with roadside inspection facilities [3].

Past years, the demand of antenna for the purpose of military applications has grown significantly within the 4.4-5.0 GHz band (C-band). There is a wide variety of military antennas and different antenna designed for particular military platforms such as air, land, and sea. Particularly, antennas used for military applications are big in size, but it is cost effective to have small size antennas. Antenna size is a major factor that limits device miniaturization. In the past few years, new designs based on the inverted-F antenna (IFA) and inverted-L antenna (ILA) and hybrid antenna made out of the combination of IFA and ILA named inverted-F-L antenna have been proposed for portable wireless devices, because these antennas are low profile [4-8]. Conventional IFAs are compact, with a length that is approximately a quarter to a half of the wavelength. These antennas can be further optimized by adding new parameters in the design, such as strategically shaping the radiating element, or judiciously locating loads [9]. The major limitation of many low-profile antennas is narrow bandwidth. Most of the conventional IFA's offer about 5% bandwidth, but wider bandwidth can be achieved by advance design method [10].

In this paper a dual band antenna is presented which is compact in size and that covers 4.4-5.0 GHz military band and 5.850-5.925 GHz ITS band. In the proposed design other limitations of general IFA are reduced and possess better performance in these two special applications. The simulation for the proposed antenna has been carried out by Numerical Electromagnetic Code (NEC) simulator and optimization of different parameters are done by trial and error methods.

## 2 ANTENNA CONFIGURATION AND DESIGN

The proposed antenna is shown in Fig. 1, where a notch with height $h_2$ has been added in the wire type IFA. Parameter studies have been conducted to ascertain the effect of different loading on the antenna performance to find out the optimal dimensions. For the study the conductor is assumed to be made of copper and the antenna was intended to be matched to 50 Ω system impedance. It can be seen that the notch is negligible in dimension but it play a vital role for improving the performance of IFA.

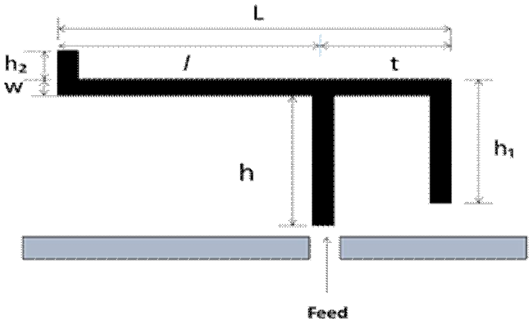


Fig. 1: Proposed dual-band modified IFA.

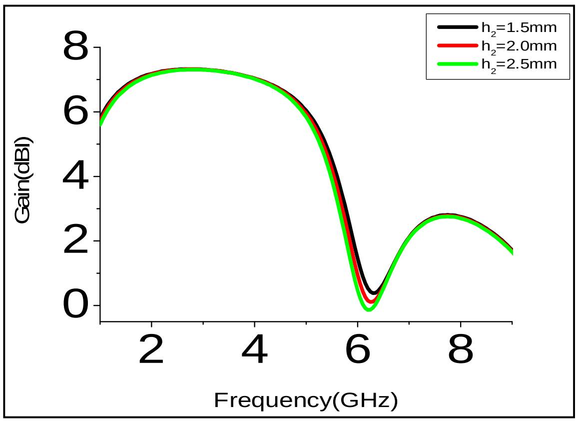


Fig. 2: Gain variations of the modified IFA with the notch height h2.

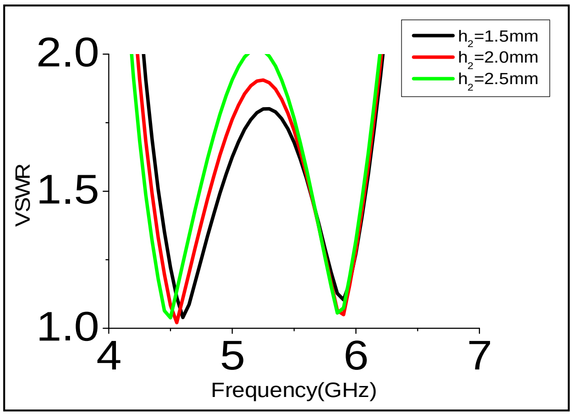


Fig. 3: SWR variations of the modified IFA with the notch height h2.

The performance of the modified inverted-F antenna is improved by varying the notch height $h_2$. The antenna has been optimized to the required 4.4-5 GHz and 5.850-5.925 GHz bands. Keeping other design parameters constant it is seen that changing the notch height the reflection coefficient is improved but gain is negligibly decrased at both operating bands. Figs. 2, 3, and 4 represent the gain, SWR and return loss variation, respectively, with the notch height. For $h_2$=1.5mm, the return loss -25.445dB, gain 6.66dBi, and SWR 1.113 at 4.55 GHz, however the return loss -26.141dB, gain 2.12dBi, and SWR 1.103 at 5.9 GHz. Also, for $h_2$=2mm, the return loss -39.817dB, gain 6.63dBi, and SWR 1.02 at 4.55 GHz, whereas the return loss -32.351dB, gain 1.61dBi, SWR 1.05 at 5.9 GHz. Furthermore, for $h_2$=2.5mm, the return loss -23.872dB, gain 6.59dBi, and SWR 1.137 at 4.55 GHz, while the return loss -28.909dB, gain 1.11dBi, and SWR 1.074 at 5.9 GHz. So, it can be seen that the modified antenna has better performance for length $h_2$=2mm. Fig. 5 shows geometric dimensions of modified inverted-F antenna with added notch $h_2$. The overall dimensions of the proposed antenna is 19 mm× 9 mm.

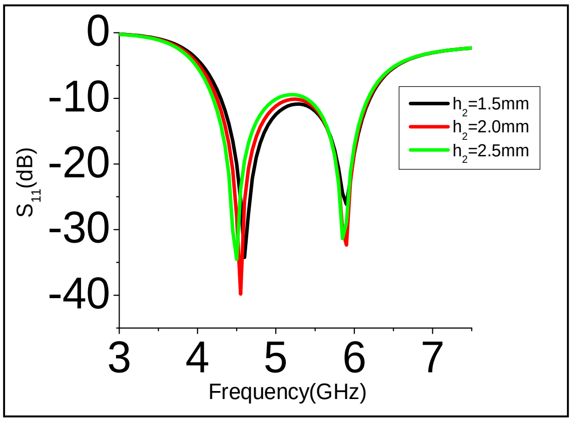


Fig. 4: Return loss variations of the modified IFA with the notch height h2.

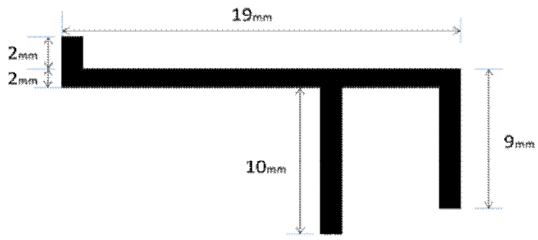


Fig. 5: Proposed modified IFA with optimized dimensions.

## 3 Simulation Results and Discussion

The antenna is designed and analysed using method of moments (MoM's) in the Numerical Electromagnetic Code (NEC). Fig. 6 shows the total gain of the proposed dual-band (military and ITS bands) IFA. The peak gains of the antenna in the military and ITS bands are 6.63 dBi and 1.61 dBi, respectively. Fig. 7 shows the VSWR variation of the modified IFA with frequency. It is found that VSWR is 1.021 and 1.05 at 4.55 GHz and 5.9 GHz, respectively, for military and ITS applications. Fig. 8 represents the return loss for the modified IFA. The antenna provides peak return loss of -39.817dB and -32.351 dB at military and ITS band, respectively.

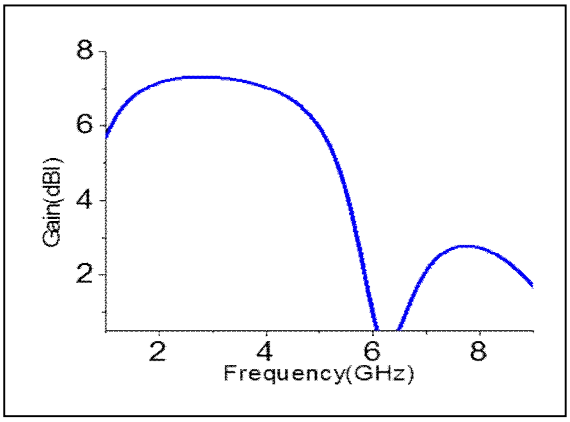


Fig. 6: Gain variation of the proposed antenna with frequency.

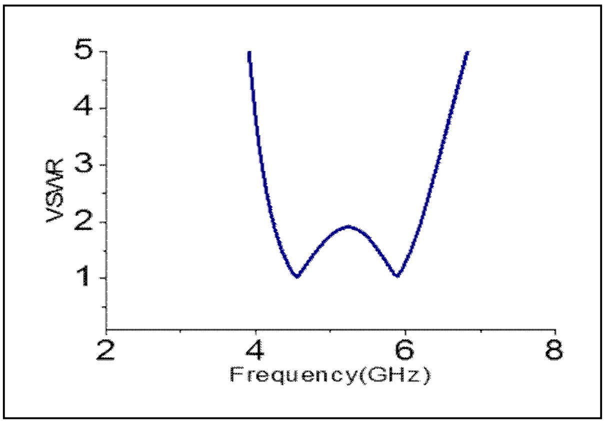


Fig. 7: SWR variation of the proposed antenna with frequency.

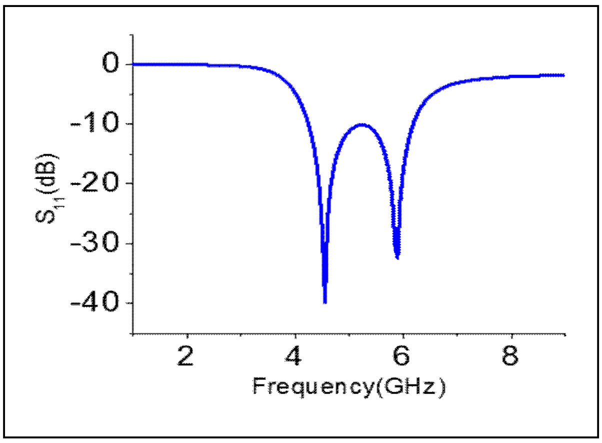


Fig. 8: Return loss variation of the proposed antenna with frequency.

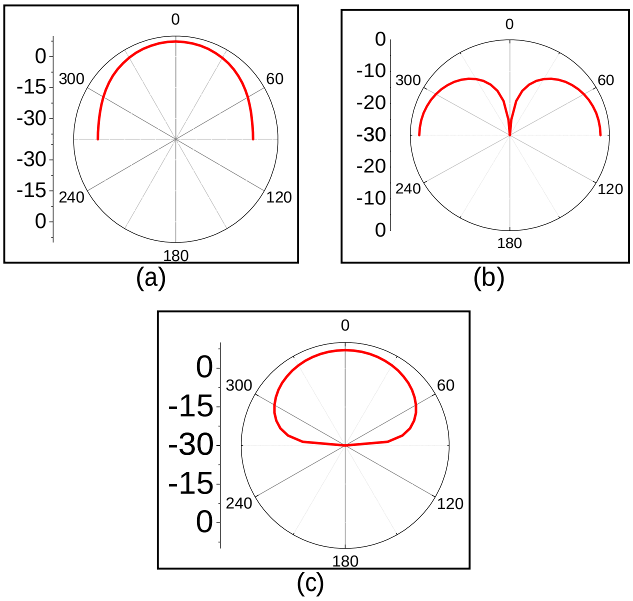


Fig. 9: Radiation patterns of the proposed antenna in vertical plane (a) total gain pattern, (b) vertical gain pattern, and (c) horizontal gain pattern.

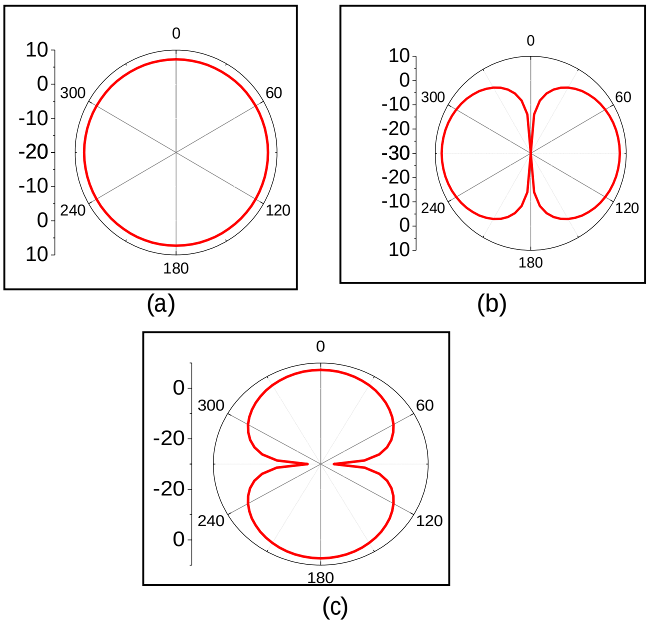


Fig. 10: Radiation patterns of the proposed antenna in horizontal plane (a) total gain pattern, (b) horizontal gain pattern, and (c) vertical gain pattern.

Figs. 9 and 10 show the radiation patterns of the antenna in vertical plane and horizontal planes, respectively. From the radiation pattern, it is realized that the antenna has acceptable radiation characteristics at both operating bands in horizontal and vertical planes. Finally, the simulated impedance and phase variation of the antenna are shown in Fig 11. The proposed antenna provides appreciable impedance at 4.4-5.0 GHz and 5.850-5.925 GHz bands as well as the phase variation is close to the 0°.

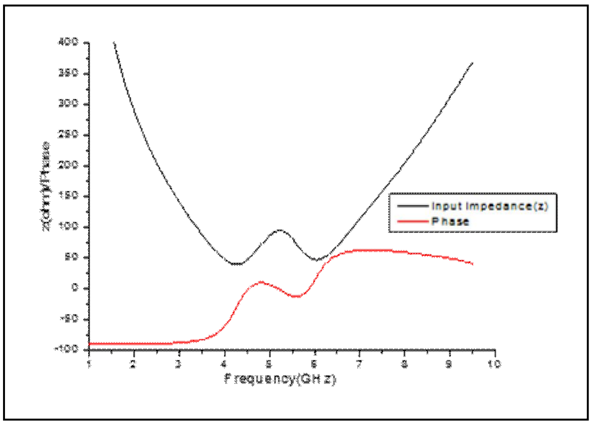


Fig. 11: Input impedance and phase variation of the proposed antenna with frequency.

## 4 Conclusion

A dual-band inverted-F antenna to achieve better performance for military and ITS applications is designed. The proposed modified IFA operates very well for the desired applications with a very small footprint. The gain, impedance, and the return loss of the antenna are satisfactory within the desired frequency bands. An intersting trade-off between reflection co-efficient and gain is obserbed in parameter study. Changing the parameter when the return loss increases the gain decreases slightly. As the effect on the gain is minor it dose not affect on total antenna performance. So, the proposed antenna can be a promising candidate for the ITS and military application.

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