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WIDEBAND INVERTED-F DOUBLE-L ANTENNA FOR 5 GHZAPPLICATIONS

Strictly as per the compliance and regulations of :

Wideband Inverted-F Double-L Antenna for 5 GHz Applications

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Abstract - An Inverted-F Double-L (IFDL) antenna with Omni-directional radiation pattern in the azimuth plane is proposed. It provides an impedance bandwidth of 2.55 GHz (5000-7550 MHz) below 10dB, which easily covers the required universal 5GHz bandwidth for wireless local area network (WLAN), and worldwide interoperability for microwave access (WiMAX).Furthermore, the antenna has a simple structure and it occupies a small size of about 19×21. mm2. This antenna also provides lower gain variation with peak return loss of -35.14, -25.795 and - 22.37 dB at 5.2, 5.5 and 5.8 GHz respectively.

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I. Introduction

In recent years due to fabulous development of mobile wireless communication, systems such as digital notepad, notebook and so on required broadband connections with large transmission and receiver speeds through wireless local area network (WLAN).Generally, the 2.4 GHZ ISM band utilized by the IEEE 802.11b and 802.11g standards but in this case the WLAN equipment will suffer interference from baby monitors, wireless keyboards, microwave oven, Bluetooth devices and other appliances that use the same band. On the other hand, the other frequency spectrum allowed for WLAN (5 GHz) have much wide band width with fewer disturbances from other services. Moreover, 5 GHz network can carry more data than the 2.4 GHz.

So, to meet the condition of less interference the design of the antenna become more sophisticated which required having some special properties such as, small size, higher gain, Omni-directional radiationpattern and so on. In order to satisfy the above condition for 5 GHz band antenna, several antennas are proposed. a monopole antenna with a folded ground strips [1] has been proposed for WLAN application is capable to satisfy the whole 5GHz band but it is not small in size.

Some of the antennas are also provide full coverage of 5 GHz but they are in large size [2-6] or require a big ground plane [7-10].Although small size is achieved by antenna presented in the literature but they suffered by inadequate coverage in 5 GHz band [1,4,5,7,10] .

Therefore, in this article, we propose a compact wideband antenna for 5GHz Universal WLAN and WiMAX operations. From the simulation results, it provides a wider impedance bandwidth of 2.55 GHz (5000-7550MHz) which fully covers the 5.2/5.5/5.8 GHz bands. Moreover it also gives an omnidirectional radiation patterns with maximum measured peak antenna gains of 7.6, 7.14 and 6.53 dBi across the operating bands, respectively. Details of the proposed antenna design are described in this study, and the related results for the obtained performance operated across the 5.2/5.5/5.8 GHz bands are presented and discussed.

II. Antenna Geometry & Design

The design variables for this antenna are the height, width, and length of the top plate, the width and the location of the feed wire.In designing the broadband low profile antenna for 5 GHz WLAN/WiMAX applications, we examine the possibility of increasing antenna bandwidth, gain and maintaining the input impedance near about 50 Ω throughout the application bands with simplifying its structure. Method of moments (MoM's) in Numerical Electromagnetic Code (NEC) [11] is used for conducting parameter studies to ascertain the effect of different loading on the antenna performance to find out the optimal design where finest segmentation of each geometrical parameter are used. The antenna is assumed to feed by 50 Ω coaxial connector. In our analysis we assume the copper conductor and the antenna was intended to be matched to 50 Ω system impedance. Fig. 1 represents the basic geometry of the different antenna. For the simulation we consider printed circuit board (PCB) with permittivity of ε_r=2.2, substrate thickness of 1.58 mm and the dimensions of the ground plane considered as 60 × 60 mm2. Fig. 1(a) represents the general IFA where one leg of IFA directly connected to the feeding and another leg spaced *s* from the ground plane. An additional L branch is added in structure 2 which shown in Fig. 1(b).In Fig 1(c) the limbs of L branch of structure 2 is extended and an additional L branch is coupled. Therefore structure 3 is termed as inverted-F Double-L antenna (IFDL antenna).

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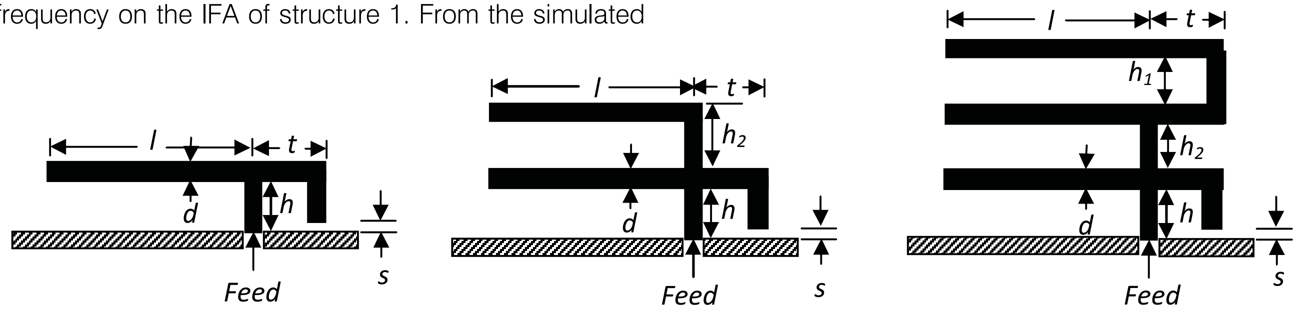
With the help of resonant frequency theory of IFA and impedance matching concept, we consider the dimension of the IFA *l=16 mm, t=5 mm, h=4 mm, h1=3 mm, d=2 mm* and *s=1 mm.* Fig. 2 shows the effects of length *l* on the return loss as a function of frequency on the IFA of structure 1. From the simulated results when *l=16 mm, t=5 mm, h=4 mm, h1=3 mm, d=2 mm* and *s=1 mm* the variation of return loss with frequency is not covering the whole 5 GHz operating band (frequency ranges 5150 – 5850 MHz) moreover the return loss is not so desirable.



(a) Structure 1, (b) Structure 2 , (c) Structure 3

Fig.1 : Geometry of different antenna structure.

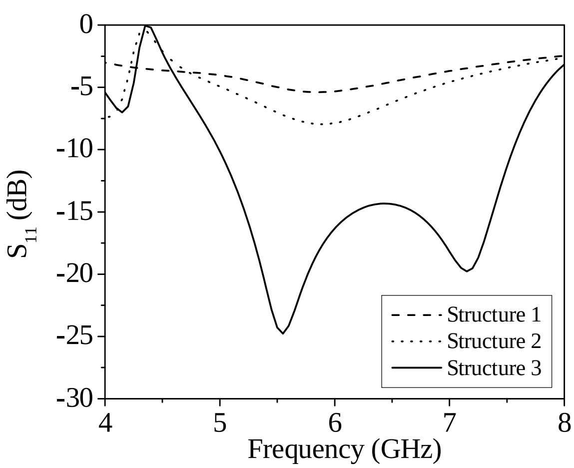


Fig.2 : Return loss as a function of frequency for different types of antennas.

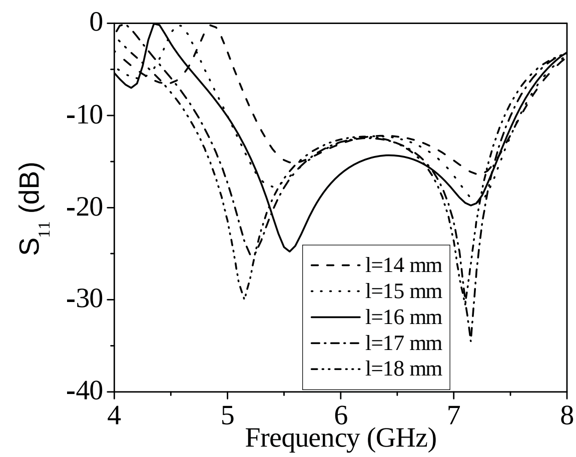


Fig.3 : Effects of length *l* on the return loss as a function of frequency on the antenna structure of Fig. 1(C).

After adding an additional L branch with the structure 1 the performance of the return loss improves slightly. However, when we added another L branch with structure 2, the performance of return loss improves dramatically. Fig. 3 shows the effects of *l* on the return loss of IFDL antenna, when *t=5 mm, h=4 mm, h1=4 mm, h2=4 mm, s=1 mm* and *d=2 mm*. From the figure we observed that, for considering return loss the best performance of the IFDL antenna is obtained when *l=16 mm although l=16 mm* and l=17 *mm* will cover the whole 5 GHz band, their return loss is not appreciable as *l=16 mm*. On the other hand, for *l=14 mm* and *l=15 mm* return loss is much higher than *l=16 mm.* Now maintaining *l=16 mm* we continue our advance analysis on the tap distance *t* as shown in Fig. 4 and we observe that when *t=5 mm* the IFDL antenna provides more negative return loss at the application bands than other values. Fig. 5 shows the effects of d on return loss when the tap distance *t=5 mm* and length *l=16 mm*. The best performance of return loss is obtained when *d=2 mm.*

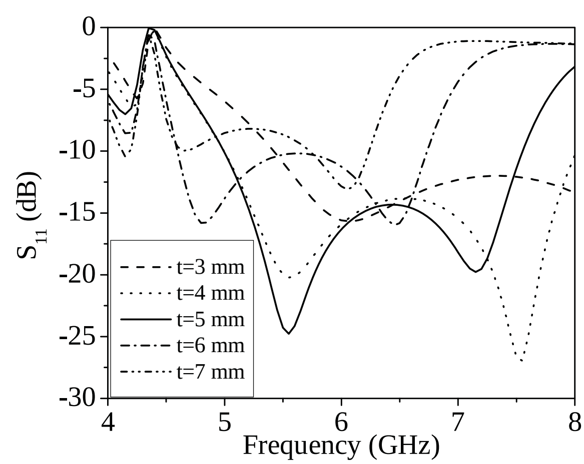


Fig.4 : Return loss as a function of frequency with the different tap distance *t* of the IFDL antenna of Fig.1(C) when *l=16 mm.*

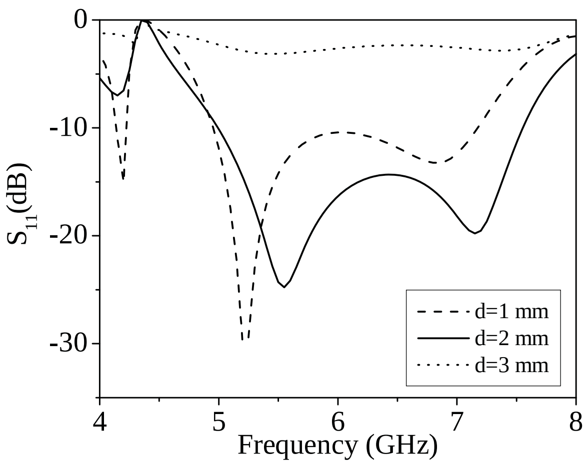


Fig.5 : Return loss as a function of frequency with different value of *d* of the IFDL antenna of Fig. 1(C) when *t=5 mm* and *l=16 mm.*

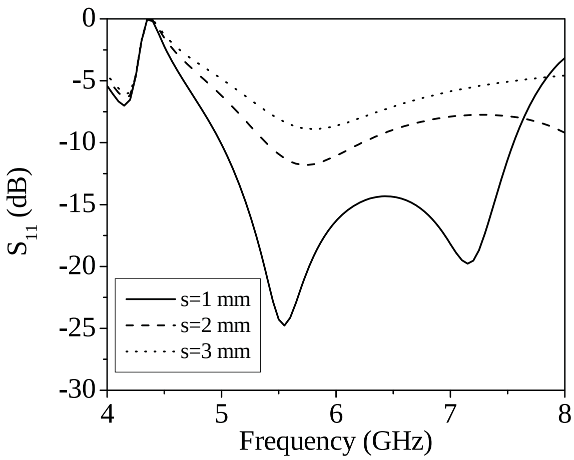


Fig.6 : Effects of spacing s on the return loss as a function of frequency on the antenna structure of Fig. 1(C)

From Fig. 6 we observe that the IFDL antenna provide best return loss performance when space from feed line s*=1 mm*. From overall analysis we see that IFDL antenna provides best performance for the desired applications. The optimized dimensions of the proposed IFDL antenna are listed in Table I.

Table 1 : Optimized dimensions of the proposed antenna

Antenna Name	Antenna Parameters	Values (mm)	Dimension (mm^2)
IFDLA	*l*	16	19×21
	t	5	
	h	4	
	h_1	4	
	h_2	4	
	d	2	
	s	1	

III. Numerical Simulation Results

The IFDL antenna provides a wide impedance bandwidth of 2.5 GHz (5000-7550 MHz) which fully covers the 5.2/5.5/5.8 GHz bands. Moreover, the IFDL antenna has the return loss appreciable than the commonly required 10 dB level. Fig. 7 and Fig. 8 show the variation of voltage standing wave ratio (VSWR) and return loss respectively. The Peak value of return loss is -14.5, -24.2 and -19.2 dB respectively. The value of VSWR of IFDL antenna varies from 1.12 to 1.55 within the operating band and obtained result indicates that the variation of VSWR is very low and it is near to 1 as shown in Fig. 7. Fig. 9 illustrates the gain of IFDL antenna. The peak gains of IFDL antenna is 7.6, 7.14, and 6.53 dBi with a very small gain variation within the 10 dB return loss bandwidth at 5.2, 5.5 and 5.8 GHz band respectively, which indicates that the antenna has stable gain within the every separate operating bandwidth.

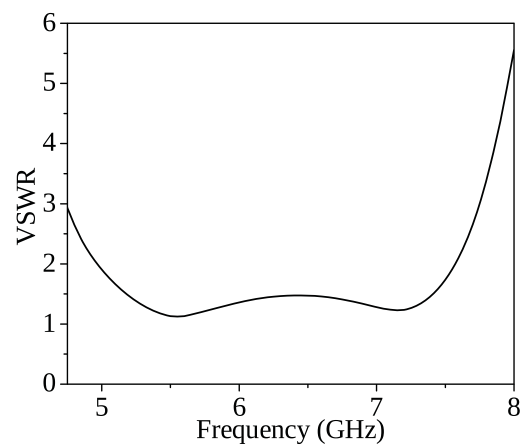


Fig.7 : VSWR variation of IFDL antenna with frequency.

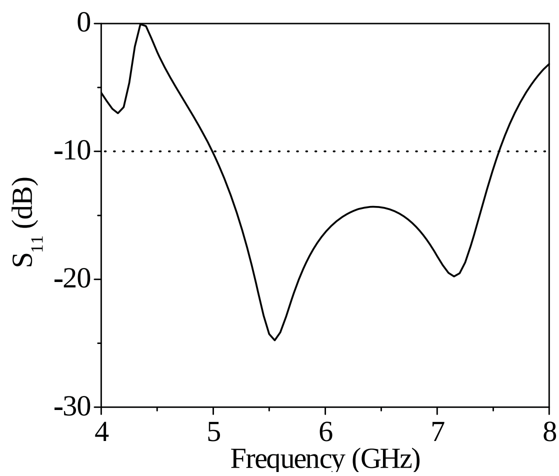


Fig.8 : Return loss variation of IFDL antenna with frequency.

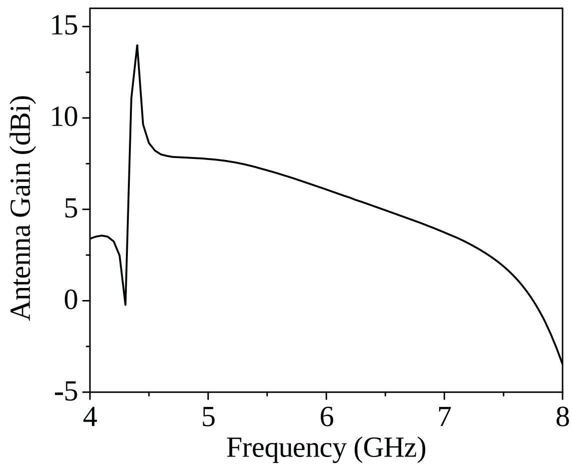


Fig.9 : Total gain variation of IFDL antenna with Frequency.

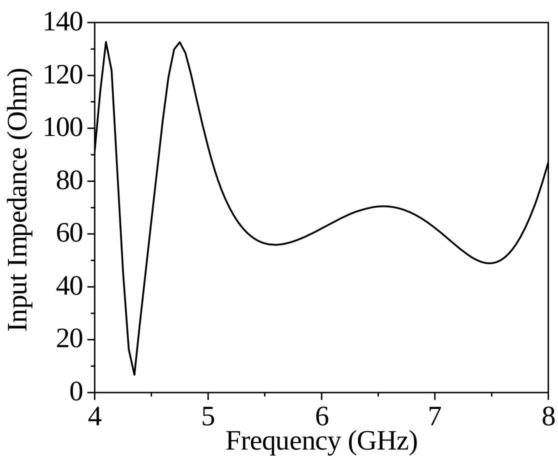


Fig.10 : Impedance variation of IFDL antenna with frequency.

Fig. 10 represents the antenna input impedance variation and Fig. 11 represents the antenna phase shift causes due the impedance mismatch as a function of frequency. From the obtained results, the input impedance of IFDL antenna is 69.05, 56.45 and 57.94Ω at 5.2, 5.5 and 5.8 GHz so the input impedance of the proposed antenna is near about 50 Ω. Also, from the simulation study, the antenna offers a phase shift of -11.2^0, -0.8^0 and 9.1^0 respectively. Therefore, phase shift of IFDL antenna closer to 0^0 all over the antenna bandwidth. A comparison in gains between the proposed (IFDL antenna) and reference antennas (Inverted-F antenna) are listed in Table II. From the table it has been observed that a significant amount of improvement resulted by IFDL antenna. A great progress experienced in return loss, VSWR, input impedance and phase.

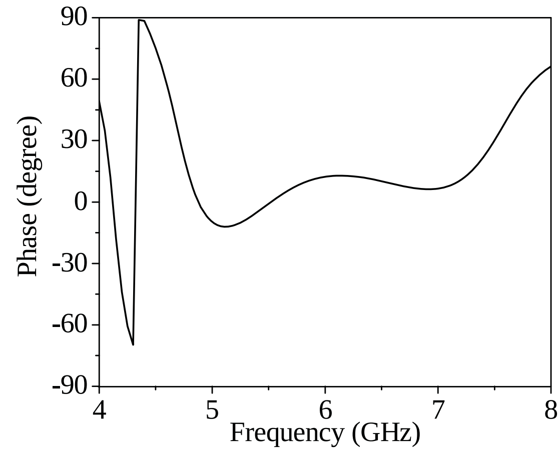


Fig.11 : Phase variation of IFDL antenna with frequency.

Figs. 12 to 14 show the normalized radiation patterns of IFDL ANTENNA at 5.2, 5.5 and 5.8 GHz bands respectively. Normalized radiation patterns for three resonant frequencies are shown as: total gain in Hplane and E-plane. The antenna's normalized total radiation in E and H-plane is almost omnidirectional at the 5 GHz WLAN and WiMAX applications. One of the significant advantages of symmetrical radiation pattern as seen from Figs. 12, 13, and 14 is that the maximum power direction is always at the broadside direction and does not shift to different directions at different frequencies.

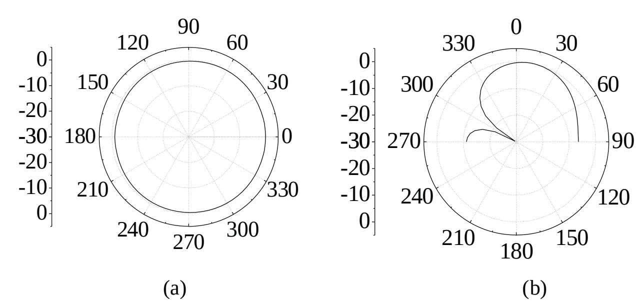


Fig.12 : Radiation pattern (normalized) (a) Total gain in E-plane and (b) total gain in H-plane of IFDL antenna at 5.2 GHz.

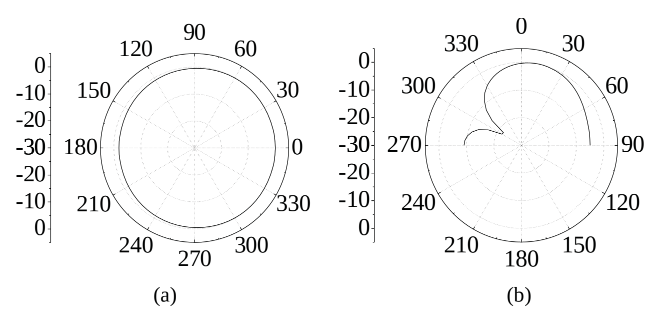


Fig.13 : Radiation pattern (normalized) (a) Total gain in E-plane and (b) total gain in H-plane of IFDL antenna at 5.5 GHz.

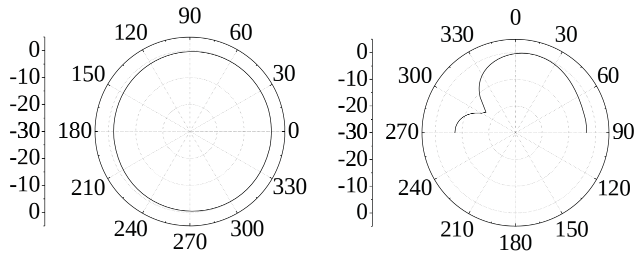


Fig.14 : Radiation pattern (normalized) (a) Total gain in E-plane and (b) total gain in H-plane of IFDL antenna at 5.8 GHz.

Table 2 : Comparison between the IFDL and IF Antenna

Antenna Parameter	IFA			IFDL		
	5.2 GHz	5.5 GHz	5.8 GHz	5.2 GHz	5.5 GHz	5.8 GHz
VSWR	4.08	3.57	3.33	1.46	1.12	1.24
Peak Gain (dBi)	7.26	7.06	6.78	7.62	7.14	6.50
Input Impedance (Ω)	45.46	20.2	15.2	69.0	56.4	57.9
Return Loss (dB)	-4.34	-5	-5.4	-14.5	-24.2	-19.2
Phase (Degree)	-57.9	-55	-26	-11.1	0.85	9.16

IV. Conclusion

In this paper we presented an Inverted-F Double-L (IFDL) antenna design. The antenna provides a sample structure with small area of 19×21 mm2. In addition, it also ensures nearly omnidirectional radiation patterns with incredibly high gain 7.6, 7.14, and 6.53 dBi across the 5.2, 5.5 and 5.8 GHz operating bands respectively. The improvement of size, input impedance, bandwidth, gain and radiation is achieved by this structure which is suitable for WLAN and WiMAX applications.

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