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# Implementation and Comparison of Minuscule ICCLMA with Minuscule Conformal Monopole Antenna

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*Abstract*—**In this** ***paper, a high gain small size antennas such as minuscule ICCLMA (Inductively Coupled Capacitively Loaded monopole antenna) with minuscule conformal monopole antenna were designed and compared. These different types of antenna topologies were designed with same dimensions to produce higher gain. We begin with the comparison between the antenna designs, requirements and continue with a discussion issues and simulation results. In fact, each technique is uniquely designed to produce size reduction and higher gain antennas. Among two antennas the minuscule ICCLMA provides high gain is 45.2dB as compared to minuscule conformal monopole antenna. The simulation results are done by using CST Microwave Studio. The minuscule conformal monopole antenna reduces the cross polarization. The minuscule ICCLMA size is 3.393X0.0474mm while the minuscule conformal monopole antenna radius is 0.113mm.***

***Index Terms— Antenna radiation patterns, lumped elements, monopole antennas, vertically polarized antennas.***

## I. INTRODUCTION

In modern research on high gain small size antennas has been developed by an increasing interest in the use of wireless communication applications. For near ground communications [13] where both the transmit and receive antennas are placed near the ground is by many orders of magnitude lower than any other antenna orientation configurations [12]. Applications such as unattended ground sensors (UGS), vertically polarized antennas with omnidirectional radiation pattern are highly desired. As [16]-[17] the antenna size reduction is obviously major problem in wireless communication devices. Therefore several methods have been investigated for extremely short monopole antennas [2]-[3] with very high lateral dimensions, while maintaining high radiation efficiency. With the development of wireless communication devices and mobile phone technology [4]-[5], it has become significant to provide low profile antennas with omnidirectional radiation pattern [6]. There are various size reduction techniques used in the design of small antennas in which reactive inductive loading and reactive capacitive loading. In [7], electrically small antennas are further investigated and the performance such as impedance matching, the radiation pattern, the radiation efficiency, quality factor (Q), and polarization to be reported. In [8], the antenna is characterized with fractal geometries and the performance, it can be summarized that increasing the fractal dimension of the antenna leads to a higher degree of miniaturization. Applications of fractal geometry are becoming mostly used in the fields of science and engineering. Antenna miniaturization can generally be categorized into two methods are Miniaturizing the antenna topology using space filling compression technique and Antenna miniaturization using magneto-dielectric materials [9]. The spatial network Method [18]-[19] provides strong radiation with an omnidirectional pattern in the horizontal direction. The dielectric truncation [14]-[15] is not close to the source, and then the space wave power is unaffected. It gives better efficiency. For certain applications, where the bandwidth can be compromised, it is found that by a comprehensive analysis of a new wide bandwidth compact antenna called (WC) wide compact J-pole antenna provided 50% impedance bandwidth [10]. Although these exist many antenna miniaturization techniques [11], most of them cannot provide high gain. However it is difficult to implement in practice, because these antennas include a multilayer geometry. An extremely (LMMMA) low profile multi element miniaturized monopole antenna [20] based on superposition of multiple quarter-wave segments that are meandered and spiraled around to suppress the radiation from horizontal currents above the ground plane. The LMMMA produces purely vertically polarization which leads to lower gain. Recently, a low profile antenna called micro inductively coupled capacitively loaded monopole antenna (ICCLMA) [1] in which the techniques such as in-plane capacitive coupling, top loading, shorting pin achieve improved polarization purity and high gain with antenna miniaturization. The minuscule ICCLMA and minuscule conformal monopole antenna [21] were compared and the simulation results were obtained.

## II. ANTENNA DESIGN

### A. *Minuscule ICCLMA*

The proposed minuscule ICCLMA with three layers of total dimension is 3.393 x0.0474mm using CST. The vertical feeding pin and shorting pin were inserted in the middle and top layer respectively. The diameters of the pins were 0.5mm. In newly developed ICCLMA, the same equivalent circuit model is to be followed by changing the lumped elements values corresponding to their enlarged gain value. The inductors L1=5nH, L2=5nH were placed in the feeding pin and shorting pin respectively and the additional inductors are L3=1.9nH, L4=1nH were inserted in the top and middle layers respectively. The shunt capacitor C1=0.788pF was placed in the metallic patch. Here the additional capacitors C2=1pF, C3=1pF were inserted into the layers because the metallic trace is narrow. The resistor R=1.5$\Omega$ was inserted into the top layer.

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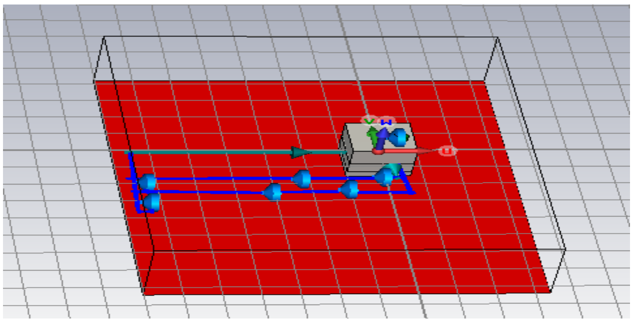


Fig. 1. Minuscule ICCLMA design with lumped elements

The antenna dimensions (length and width) were calculated by using the formula as given by,

$$L = \frac{\lambda_0}{2} = 2\Delta L \quad (1)$$

L=3.393mm

where $\Delta L$ denotes the dimension of the patch and L denotes the actual length of the antenna.

$$\Delta L = 0.412h \frac{(\varepsilon_{reff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon_{reff}-0.258)\left(\frac{W}{h}+0.8\right)} \quad (2)$$

$\Delta L$ = 1.69mm

where h represents the height of the substrate.

Width of the antenna is calculated by using the formula is given by,

$$W = \frac{c}{2f_0}\left[\sqrt{\frac{2}{(\varepsilon_r+1)}}\right] \quad (3)$$

$W$ = 0.0474mm

where $\varepsilon_r$ represents the dielectric constant, f represents the frequency range, and C represents the velocity of light.

The effective dielectric constant ($\varepsilon_{reff}$) is given by,

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1+12\frac{h}{W}\right]^{1/2} \quad (4)$$

$\varepsilon_{reff}$ = 2.21

### B. *Minuscule Conformal Monopole Antenna*

The proposed minuscule conformal monopole antenna of radius is 0.113mm using CST. The design procedure for minuscule conformal monopole antenna is following. First the antenna is adapted to the cylinder. The cylindrical antenna is designed by the radius and height is 0.113mm and 0.0157mm respectively. Then the feed point is inserted to the cylindrical antenna. The feed point radius and height is given by .05mm and 0.0626mm respectively. The lumped elements such as resister R=100Ω and capacitor C=1.5pF are connected between the cylindrical antenna and the feed point.

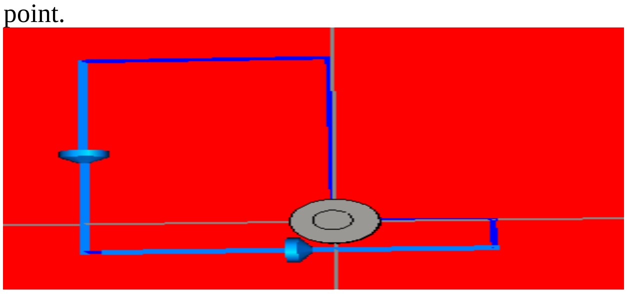


Fig. 2. Minuscule conformal monopole antenna design with lumped elements.

Antenna input impedance and admittance of the antenna were obtained is given by,

$$X_f = \frac{L}{2\sqrt{\varepsilon_{reff}}} \quad (5)$$

$X_f$ = 1.14mΩ

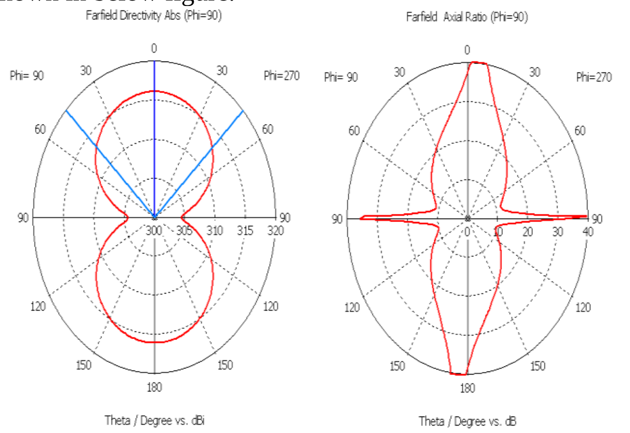
$$Y_f = w/2 \quad (6)$$

$Y_f$ =0.237mho

Where Xf and Yf is the antenna input impedance and admittance.

## III. SIMULATION RESULTS

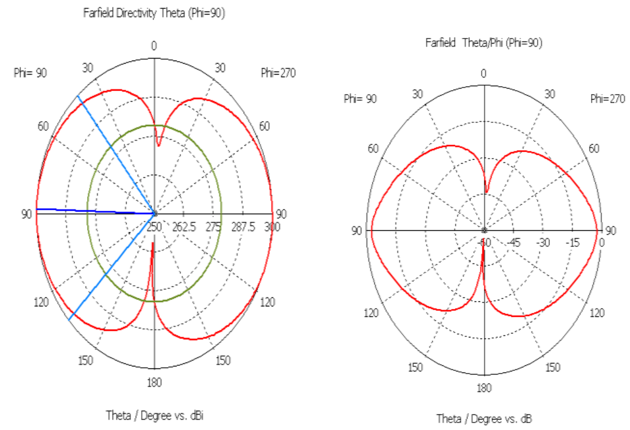
I) We designed the minuscule ICCLMA topology using CST software and the corresponding simulation results were shown in below figure.




(a) (b)

Fig. 3. Simulated (a) Farfield directivity abs (Phi=90˚) and (b) Farfield axial ratio (Phi=90˚) in minuscule ICCLMA design.

In the above figure 3 (a) shows farfield directivity absolute value at Phi=90˚. It provides the figure of eight radiation pattern. Here the frequency as 2.5GHz and the main lobe magnitude value as 316.0dB. Fig. 3(b) shows the farfield directivity axial ratio at Phi=90˚.The main lobe magnitude as 40.0dB. The gain of this minuscule ICCLMA is 45.2 dB.




(a) (b)

Fig. 4. Simulated (a) Farfield directivity theta (Phi=90˚) and (b) Farfield directivity Theta/phi (Phi=90˚) in minuscule ICCLMA design.

The corresponding farfield directivity theta at Phi=90˚ is shown by Fig. 4(a). It provides the figure of eight radiation pattern and the main lobe magnitude as 299.8dB,the main lobe direction as 88.0deg and the angular width as 92.6 deg.


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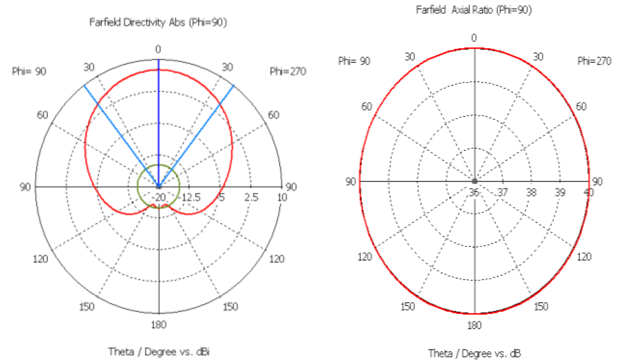
Fig. 4(b) shows the farfield directivity Theta/phi Phi=90˚. Here the main lobe magnitude as -2.5dB.

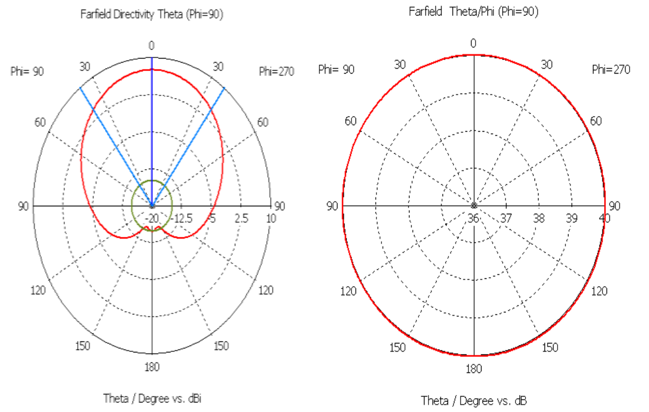
II) We designed the minuscule conformal monopole antenna using CST software and the corresponding simulation results were shown in below figure.




(a) (b)

Fig. 5. Simulated (a) Farfield directivity abs (Phi=90˚) and (b) Farfield axial ratio (Phi=90˚) in minuscule conformal monopole antenna design.

In the above figure 5(a) shows farfield directivity absolute value at Phi=90˚. Here the frequency as 2.5GHz and the main lobe magnitude value as 7.4dB. Fig. 5(b) shows the farfield directivity axial ratio at Phi=90˚. It provides the omnidirectional radiation pattern. The main lobe magnitude as 40dB.




(a) (b)

Fig. 6. Simulated (a) Farfield directivity theta (Phi=90˚) and (b) Farfield directivity Theta/phi (Phi=90˚) in minuscule conformal monopole antenna design. The corresponding farfield directivity theta at Phi=90˚ is shown by Fig. 6(a). The main lobe magnitude as 7.4dB, the main lobe direction as 0.0deg and the angular width as 74.5 deg. Fig. 6(b) shows the Farfield directivity Theta/phi (Phi=90˚). It provides the omnidirectional radiation pattern. Here the main lobe magnitude as 40dB. The gain of minuscule conformal monopole antenna is 1.06dB. The proposed minuscule ICCLMA provides higher gain as compared to the minuscule conformal monopole antenna.

**TABLE I. Comparison between Minuscule ICCLMA and Minuscule Conformal Monopole Antenna**

| Parameters | Minuscule ICCLMA | Minuscule Conformal Monopole Antenna |
|---|---|---|
| **Dimension** | 3.393x0.0474mm | 0.113x0.0157mm |
| **Main lobe magnitude** | 316.0dBi | 7.4dBi |
| **Gain** | 45.2dB | 1.06dB |
| **Beam width** | 89.9˚ | 74.5˚ |
| **Main lobe direction** | 90.0˚ | 0.0˚ |
| **Frequency** | 2.5GHz | 2.5GHz |
| **S-Parameter magnitude in dB** | -6.736 | -19.217 |

## IV. CONCLUSION

In this paper, implementation and performance comparison of minuscule ICCLMA and minuscule conformal monopole antenna were presented using CST and the radiation pattern performance of the E-plane and H-plane pattern are obtained. The minuscule ICCLMA topology provides better reduction in size, improved polarization purity and high gain as compared to minuscule conformal monopole antenna design. The reduced size of the minuscule ICCLMA and minuscule conformal monopole antenna are suitable for mobile radio communications, wireless communications.

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## REFERENCES

1. Jungsuek Oh and Kamal SarabandI (2012)," Low Profile, Miniaturized Inductively Coupled Capacitively Loaded Monopole Antenna", IEEE Trans. Antennas Propag., vol. 57, no.1,pp. 1206-1213.
2. Hong W, Behdad N, and Sarabandi K (2004) "Size reduction of cavity backed slot antennas", IEEE Trans. Antennas Propag., vol. 54, pp. 1461–1466.
3. Behdad N and Sarabandi K (2004), "Bandwidth enhancement and further size reduction of a class of miniaturized slot antennas", IEEE Trans. Antennas Propag., vol. 52, pp. 1928–1935.
4. Goubau G (1976), "Multielement monopole antennas", in Proc. Workshop on Electrically Small Antennas ECOM, Ft., Monmouth, NJ, pp.63–67.
5. Rowell C .R and Murch R. D (1997), "A capacitively loaded PIFA for compact mobile telephone handsets", IEEE Trans. Antennas Propag., vol.45, pp. 837–842.
6. Hala Elsadek (2011), "Microstrip Antennas for Mobile Wireless Communication Systems" CC BY-NC-SA 3.0 license, in subject Electrical and Electronic Engineering.
7. Steven R.Best (2011), "A Discussion on Electrically Small Antennas Loaded with High Permittivity and Permeability Materials", The MITRE Corporation.
8. Kulbir Singh, Vinit Grewal, Rajiv Saxena (2009), "Fractal Antennas: A Novel Miniaturization Technique for Wireless Communications", ECED, Thapar University, Patiala, India; National Institute of Technology, Jalandhar, India; Jay Pee Institute of Engineering and Technology, Raghogarh, Guna, M.P, India.
9. Brad A. Kramer (2007), "Size reduction of an UWB low-profile spiral antenna", Ohio State University, Electrical Engineering.


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10. Minh-Chau Huynh (2004), "Wideband compact antennas for wireless communication applications", Virginia Polytechnic Institute and State University,
11. Chiu C.Y, Shum K.M and Chan C.H (2007), "A tunable via-patch loaded PIFA with size reduction", IEEE Trans. Antennas Propag., vol. 55, no.1, pp. 65–71.
12. Liao D and Sarabandi K (2008), "Terminal-to-terminal hybrid full-wave simulation of low-profile, electrically-small, near-ground antennas", IEEE Trans. Antennas Propag., vol. 56, no. 3, pp. 806–814.
13. Liao D and Sarabandi K (2005) "Optimization of low-profile antennas for applications in unattended ground sensor networks", IEEE Trans. Antennas Propag., vol. 53, no. 11, pp. 3747–3756.
14. Bhattacharyya (1991), "Effects of ground plane and dielectric truncations on the efficiency of a printed structure", IEEE Trans. Antennas Propag. vol. 39, pp. 303–308.
15. Huynh M.C. and Stutzman W (2003) , "Ground plane effects on the planar inverted-F antenna (PIFA) performance", IEE Proc. Microwave Antennas Propag., vol. 150, no. 4, pp. 209–213.
16. Herscovivi N and Diadem E (1999), "Omni directional antennas for wireless communication", in Proc. IEEE Int. Symp. Antennas Propag. vol. 1, pp. 556–559.
17. McLean J, Foltz H, and Crook G(1999), "Broadband, robust, low profile monopole incorporating top loading, dielectric loading, and a distributed capacitive feed mechanism", in Proc. IEEE Int. Symp. Antennas Propag, vol. 3, pp. 1562–1565.
18. Taga T and Tsunoda K (1991), "Analysis of a planar inverted-F antenna by spatial network method" , IEICE, B-2, vol. J74-B-2, no. 10, pp.538–545.
19. Sekine S , Ito T , Odachi N, Murakami Y and Shoki H (2003), "Design method for a broadband inverted-F antenna by parallel resonance mode", IEICE, B, vol. J86-B, no. 9, pp. 1806–1815.
20. Hong W.B and Sarabandi K (2009),"Low-profile, multi-element, miniaturized monopole antenna", IEEE Trans. Antennas Propag., vol. 57, no.1, pp. 72–80.
21. Yan-Tao Li, Xiao-Lin Yang, Zhao-Bo Li, Lei Wang, and Hong-Chun Yang (2011)." A unidirectional cylindrical conformal monopole antenna designed for impulse radar system", IEEE Antennas and wireless propagation letters. Vol. 10, pp. 1397-1400.


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