Fully-Integrated Shark-Fin Antenna using LTE and WiMAX/WLAN Applications

Author

GC Abdul Mouiz Ahmed Naik

GC Muhammad Usman

GC Salman Nasir

PC Muhammad Waqar

Supervisor

Lec Maryam Rasool

Submitted to the faculty of Department of Electrical Engineering,

Military College of Signals, National University of Sciences and Technology,

in partial fulfillment for the requirements of B.E Degree in Electrical Engineering

July, 2020

Fully-Integrated Shark-Fin Antenna using LTE and WiMAX/WLAN Applications

By

GC Abdul Mouiz Ahmed Naik

GC Muhammad Usman

GC Salman Nasir

PC Muhammad Waqar

Supervisor

Lec Maryam Rasool

Submitted to the faculty of Department of Electrical Engineering,

Military College of Signals, National University of Sciences and Technology,

in partial fulfillment for the requirements of B.E Degree in Electrical Engineering

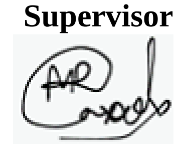
July, 2020

CERTIFICATE OF CORRECTIONS & APPROVAL

Certified that work contained in this thesis titled "Shark Fin Antenna", carried under the supervision of Lec Maryam Rasool for partial fulfillment of Degree of Bachelors of Electrical Engineering, in Military College of Signals, National University of Sciences and Technology, Islamabad during the academic year 2019-2020 is correct and approved. The material that has been used from other sources it has been properly acknowledged / referred.

Approved by

Supervisor



Lec Maryam Rasool

Date: 09-07-2020

DECLARATION

No portion of work presented in this thesis has been submitted in support of another award or qualification in either this institute or anywhere else.

Plagiarism Certificate (Turnitin Report)

This thesis has been checked for Plagiarism. Turnitin report endorsed by Supervisor is attached.

GC Abdul Mouiz Ahmed Naik
Signature of Student

00000199934

Registration Number

Signature of Supervisor

Acknowledgements

I am grateful to Allah Almighty for not leaving me alone stranded in the island of confusion and disparity when the things got difficult. He guided me and helped me through this process of achieving this great accomplishment. Surely, he is worthy of all praise.

I am thankful to my parents who cared for me and smothered me when I needed moral support. Their affection will always be in my heart, forever.

I would also like to thank Lec Maryam Rasool for being on my path of guidance. I am also thankful to GC Adnan Rafique, my colleague for being there to show me the right path to this achievement which I could not have seen without him.

Finally, I would like to express my love to those who upheld my moral support when I needed the most to achieve this accomplishment.

Dedicated to my lovely parents and the rest of Muslim Ummah.

Abstract

With the advent of internet of things and increase demand of high technology to keep up with the worlds fast pace evolution in the fields of science, everything is connected to internet for communication purposes and ease for the mankind. Shark-fin antenna is solely for the communication between vehicles for better driving conditions and to avoid accidental incidents. Shark-fin antenna operates on the modern frequencies of LTE (long term evolution) and WiMAX/WLAN for speedy and efficient communication between automobiles. The traditional whip antenna could not serve the purpose of communication with vehicles, so there is a need for antenna which can provide that. That antenna must work on the frequencies with higher band to communicate within the milliseconds to avoid the collisions in traffic in time. Shark-fin antenna is the antenna which serves the purpose and does not work on one modern frequency but two of them which are common and is the latest in today's science. For better and safer driving environment, we do require the communication between vehicl**es**. And it will be provided by Shark-fin antenna. With increase production of automobiles for general public and overall population of world, the world has finite space for accommodation. Science is working hard for the safety of population and minimizing the risks for public. As the automobiles on roads are increasing, the incidents involving human sacrifices are also increasing. According to world health organization (WHO), annually 1.35 million people die from road traffic accidents. To cover up for such problems and risks we need to develop an intelligent traffic solution. Shark-fin antenna provides such a solution to minimize such happenings and increase the overall life span of public by avoiding the road accidents by providing the communication between the vehicles for sharing traffic information.

Key words: *Vehicle communication, traffic information, modern frequencies, LTE, WiMAX/WLAN*

TABLE OF CONTENTS

List of figures

1. Chapter 1: Introduction

1.1 History of Antennas:

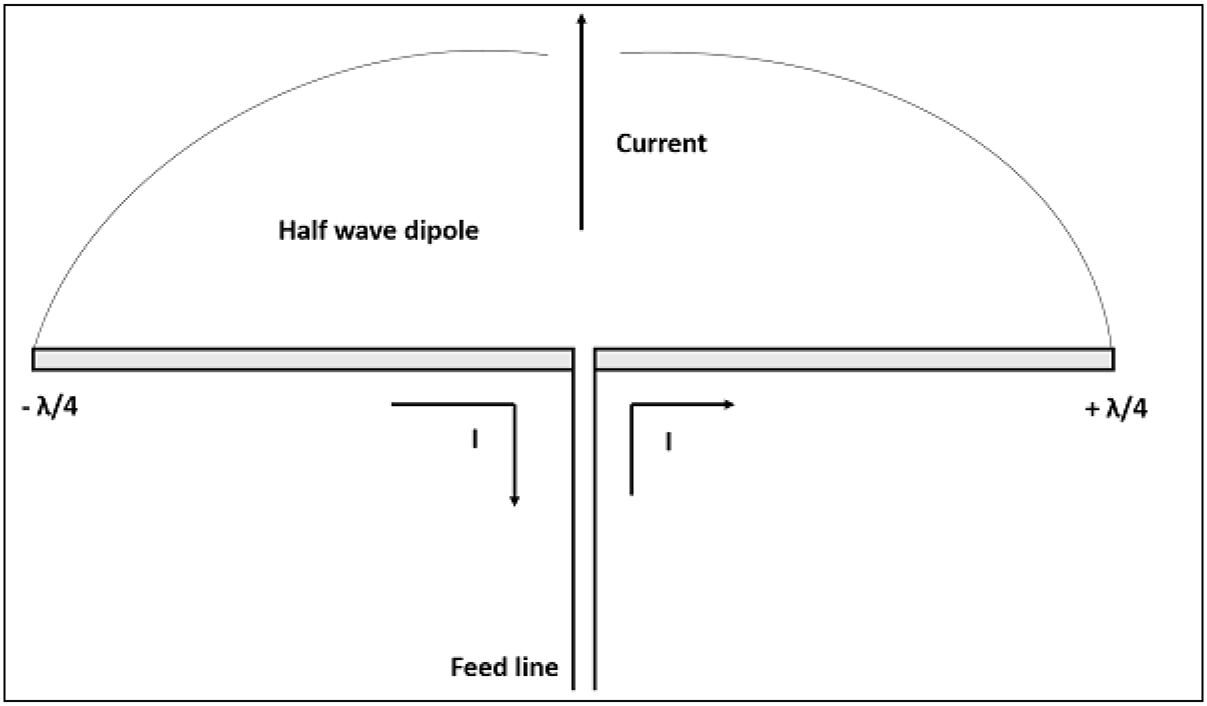
Basically, an antenna can be defined as a conductor or an array of it which can receive or transmit radio signals. Different historians have different belief about which was the first antenna ever made. But most widely accepted and widely noticed by historians is the antenna created in the 1888 by German Physicist named Heinrich Hertz. It was simply a basic functional small antenna made to actually show the waves in our atmosphere which was predicted by James Clerk Maxwell and hence it successfully proved it by dipole antennas. In 1895, the scientist Marconi started to develop an antenna which was used to wirelessly send messages over long distances i.e. telegraphy. He won a Nobel Prize over such an incredible discovery.

(Fig 1.1 Heinreich Hertz)

1.2 Types of Antennas based on structure

1.2.1 Dipole antenna:

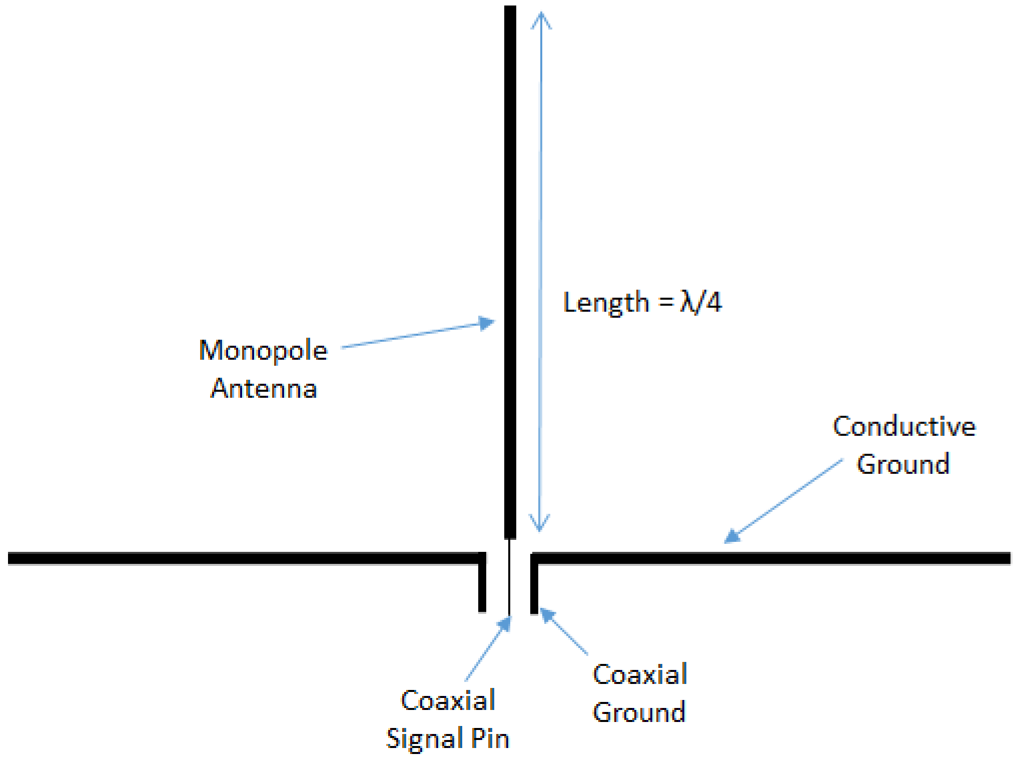
Theoretically the most simplest and basic form of antenna are dipole antenna. Dipole antenna simply consists of two equilength (of equal length) conductors end to end. The feed line is between them connected. These antennas are sometimes also called resonant antennas.



(Fig 1.2 Dipole Antenna)

1.2.2 Monopole Antenna:

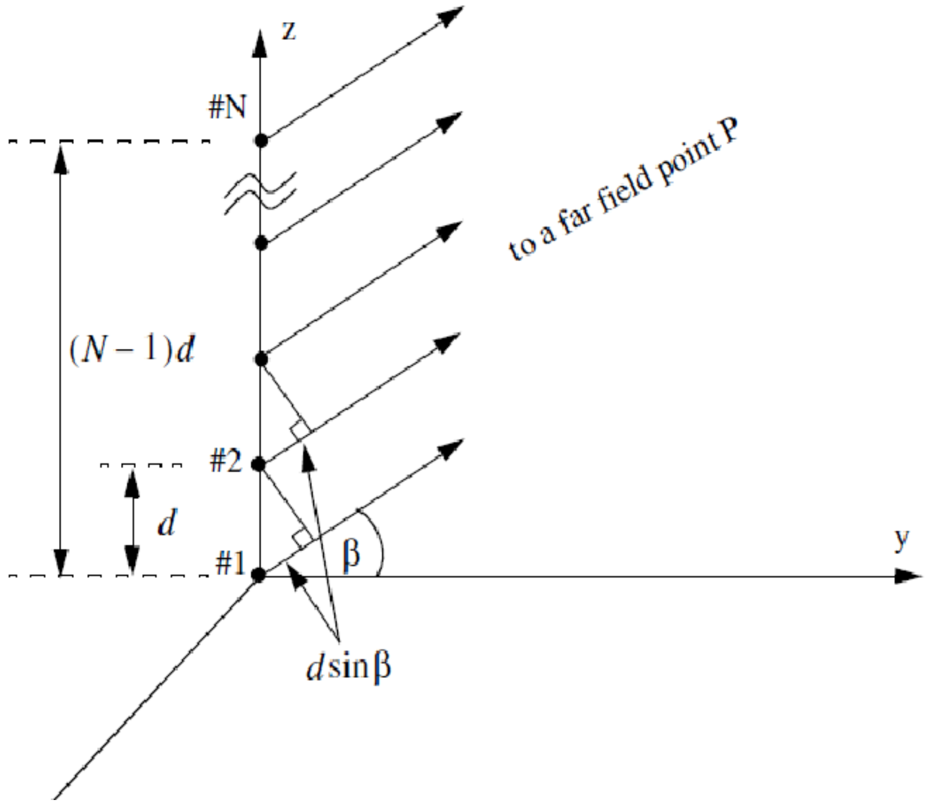
It can be defined as a class of radio antenna with the shape of straight rod type conductor fixed and upheld on the ground conductive surface with feed lines' one end connected with rod and the other with ground plane. The straight rod shaped conductor is often placed perpendicular to the ground. Monopole antennas are also resonant antennas.



(Fig 1.3 Dipole Antenna)

1.2.3 Array Antenna:

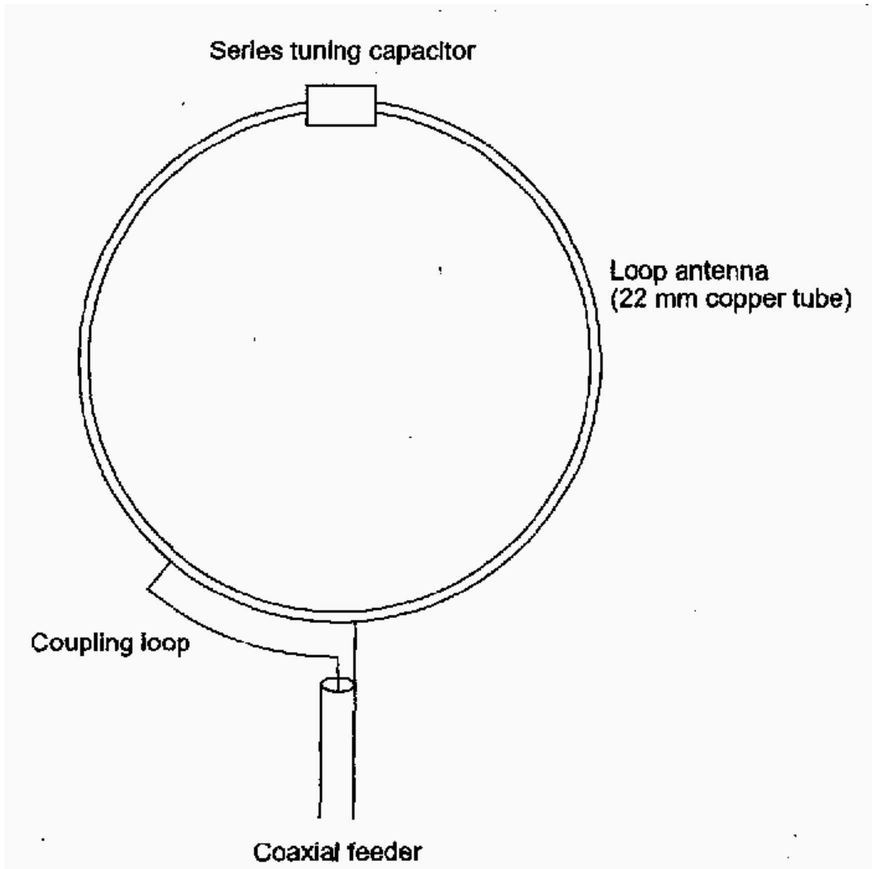
This antenna has 2 and sometimes more antennas connected in array to work as such as a single antenna. Array antennas are used for better performance over the single antenna as it provides with greater gain and better improvement in performance.



(Fig 1.4 Array Antenna)

1.2.4 Loop Antenna:

It is the antenna consisting of a loop of a conducting material fed by balanced source. Large loop antenna and small loop antenna are the two classes in which loop antenna is divided into. Large loop antenna has the circumference of its loop equal to one wavelength of its operating frequency. While small loop antenna have circumference smaller than its wavelength of operating frequency.

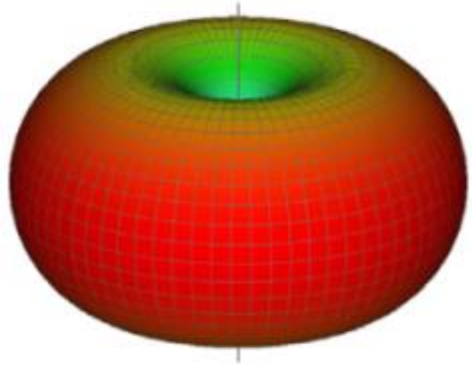


(Fig 1.5 Loop Antenna)

1.3 Types of Antennas based on radiation

1.3.1 Omni-Directional Antennas:

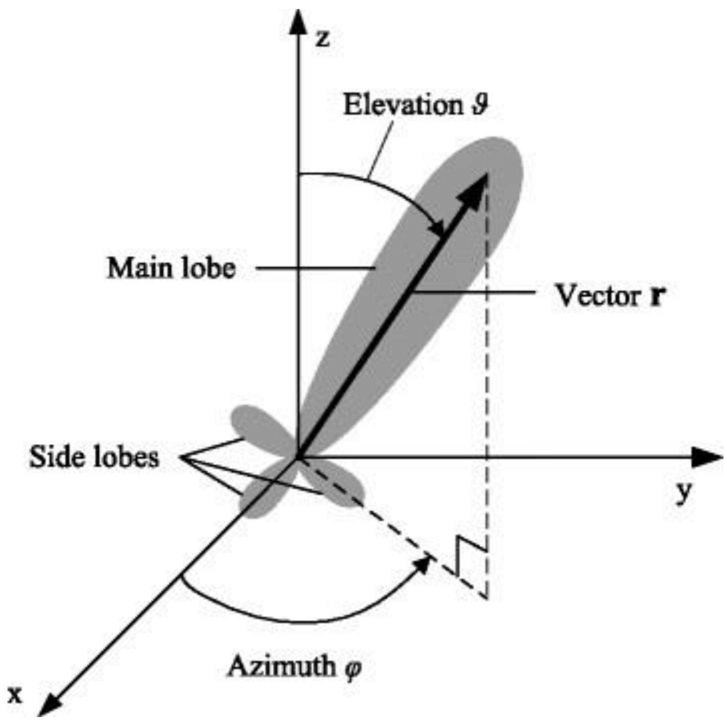
This is the class of antenna in radio communication which radiated and transmits waves in all directions perpendicular to its own axis. It has radiation pattern in a circular shape or something within the class of circular shape. The power radiated varies with the angle to its axis and it is zero at its origin [1].



(Fig 1.6 Omni Directional Antenna)

1.3.2 Directional Antennas:

This class of antenna is the one which radiates waves and maximum power at a certain direction according to the geometry and design of antenna, for what purpose it is made. This is mainly used to have better reception at communication. The directional antenna has a radiation pattern with main lobe at the direction required and the side lobes which radiate smaller power at other different directions. The maximum power is in the main lobe [1].



(Fig 1.7 Directional Antenna)

1.4 Vehicular Antennas

Vehicular antennas are integrated on automobile to have better reception and communication on the move [3]. In our daily lives, vehicular whip antennas can be seen on the common automobiles which are mainly used for AM and FM radio waves to log into the radio stations. In military vehicles, better form of whip antennas are seen so different vehicles can communicate with each other on the move for passing out orders [4]. The vehicular antennas must be as high as they can be from the ground for better reception and the receiver antenna must not be far from transmitting antenna so the receiving antenna is not attenuated way too much. As the technology is advancing, the needs are advancing too [5]. With the immergence of IoT, smart cars require antennas which can operate on higher frequencies for speedy communication like LTE, GPS, and WAVE etc [6].

2. Chapter 2: Literature Review

2.1 Overview

Shark-Fin antenna is an ideal antenna for the vehicles which require fast and speedy communication on the move operating on higher frequencies like LTE, WIMAX/WLAN. With its greater gain and better return loss, while being still in compact size the antenna is great for the very sole purpose it is made. The antenna is fixed with in a shark fin case which has good aerodynamic features minimizing noise cancellation. Shark-fin antenna is the final solution for achieving the communication between automobiles.

2.2 Achieving Multiple bands:

The multiple bands of LTE and WiMAX/WLAN are achieved with a single planar inverted F antenna (PIFA) which is mounted on top of a ground plane [7]. The PIFA is notched and cut at certain angles for the minimizing the return loss.

2.3 Planar Inverted F Antenna:

The planar inverted F antenna (PIFA) is the antenna for wireless communication. It has monopole antenna connected to the ground plane [8]. The other point of contact of PIFA is the feeding point, touching both the planar inverted F antenna and the ground plane. The antenna then is fed from that point. In shark-fin antenna, PIFA is used to achieve the desirable results.

2.4 Substrate

2.4.1 Ground:

The substrate for the ground used is the copper. Copper is used due to its properties which help with minimizing the return loss and thus achieving better results [9].

2.4.2 PIFA:

The substrate for PIFA is also copper due to its properties. Hence, we are achieving the lesser return loss and greater gain [10].

2.5 Shark Fin case:

2.5.1 Importance of shape:

The Shape of Shark fin case is important because it helps to minimize noise cancellation due to its aerodynamic shape [11]. The shark fin case can be painted into any color to suit the vehicle color as opposed to traditional whip antennas. As automobiles are also becoming a thing of fashion, so the shape of the case suits the purpose because of its beautiful and minimalist design.

2.5.2 Printing of Shark Fin case:

The shark fin case is 3D printed from the stl file. The case is made of plastic and hence is colored by our own choice.

(Fig 2.1 Shark Fin Case 3D printed)

2.6 Summary

2.6.1 Problem:

With the emergence of modernism in technology, the communication on the move requires better reception and speedy coverage operating on the higher frequencies. The old tradition vehicular whip antennas fail to fall in a category because they are incompatible with higher frequencies. The shark fin antenna thus operates on the higher frequencies to achieve the maximal results of communication on the move.

2.6.2 Proposed Solution:

The solution to the problem is to design a fully integrated antenna called Shark-Fin antenna enclosed in a shark fin like case operating on modern frequencies for vehicular communication with greater gain and minimal return loss [12].

2.6.3 Material used:

The substrate used for the designing of antenna is copper and for shark fin case, plastic is used with hollow body.

2.6.4 Thickness of substrate:

The copper substrate of ground is 1.8mm in thickness and the copper substrate of planar inverted F antenna (PIFA) is 1.5mm in thickness [13].

2.6.5 Feed:

The feed is the point of antenna which is electrically active. It is 1mm in length and 2mm in width.

2.6.6 Ground:

The ground plane of antenna is copper with thickness of 1.8mm, 95mm in length and 50mm in width.

2.6.7 Shark fin case:

The shark fin case in which the antenna will be enclosed has dimensions greater than antenna so it could fit in it. The case is 3D printed in plastic.

2.6.8 Objectives:

2.6.8.1 Academic objectives:

The designed antenna is with high positive gain and minimum return loss, efficient radiation pattern, and great isolation characteristics.

2.6.8.2 Application objectives:

The Shark-Fin antenna aims at sharing information of traffic in the newly made intelligent systems of transportation and telematics to avoid accidents involving traffic using LTE and WiMAX/WLAN communication bands for creating a safer driving environment.

3. Chapter 3: Antenna Design and Development

3.1 Software

3.1.1 High Frequency Structural Simulator 13.0 (HFSS):

High Frequency Structural Simulator 13.0 (HFSS) is used to design antennas, achieving and testing its results. HFSS is used due to its unique computational functionality for designing antennas and fast and accurate simulations in real time [14]. HFFS is a complete package and is being used in institutional and professional level for very long time. Hence, we used HFSS for same reasons. In particular, we selected version 13 of HFSS because of its stability and efficiency.

3.1.2 3D case design:

The 3D case design of shark fin case is made in the software SketchUp Pro 2020. SketchUp Pro 2020 is a free to use software with wide varieties of options to make unique shape in stl file. SketchUp Pro 2020, comparative to its competitors puts other software to shade due to its use of ease and perfection. For this purpose, we used SketchUp Pro 2020 to design a stl file of our shark fin case [15].

3.1.3 Fabrication of Antenna:

The antenna after being designed in hfss is fabricated and made in hard form from soft form.

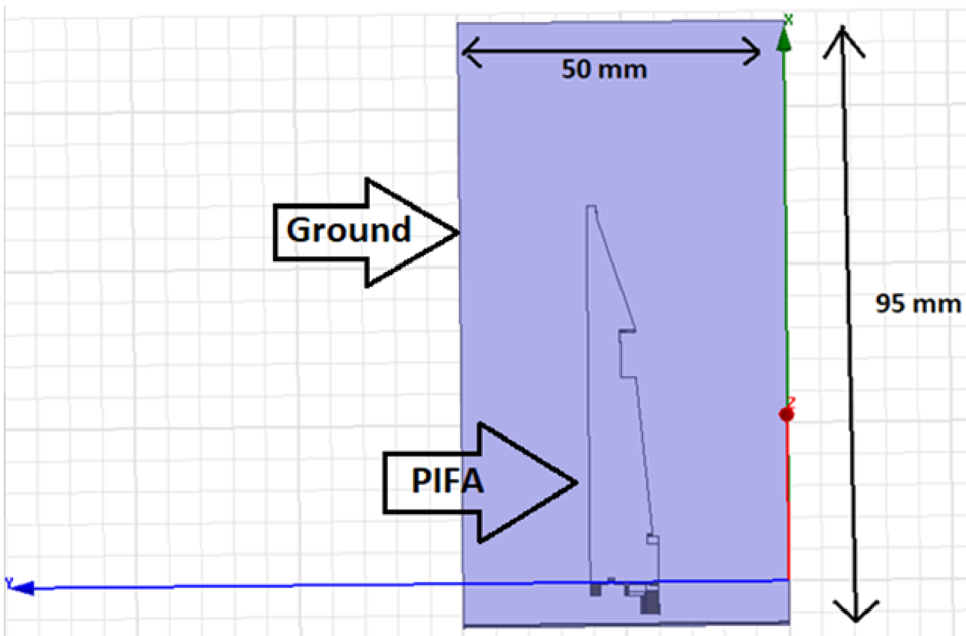
3.1.4 Results measured:

After fabrication of antenna, the results of antenna are measured and run at the required high frequencies for communication on the move.

3.2 Antenna and Case design

3.2.1 Dimensions of Antenna:

3.2.1.1 Dimensions of Ground:



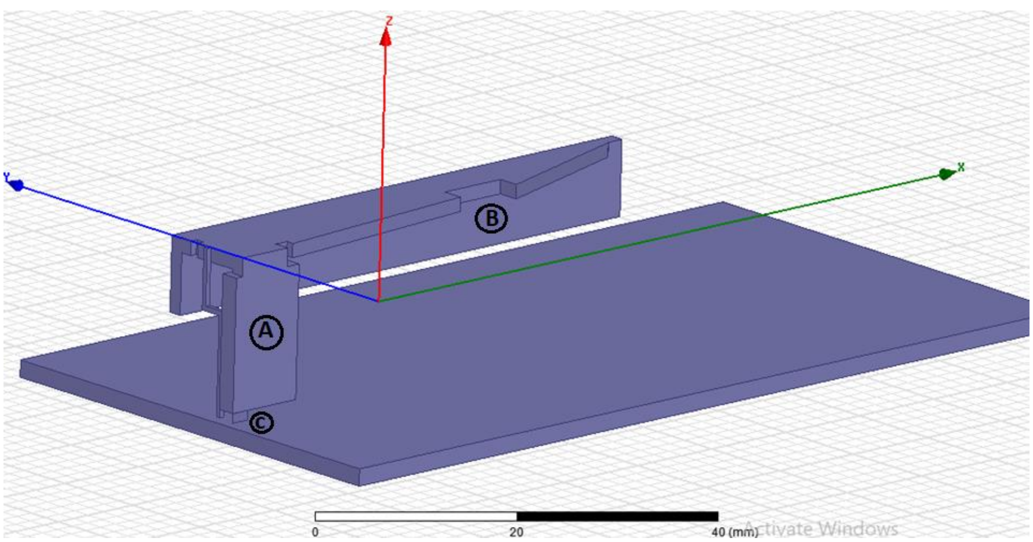
(Fig 3.1 Dimensions of Ground)

X Size= 95 mm, Y Size= 50 mm

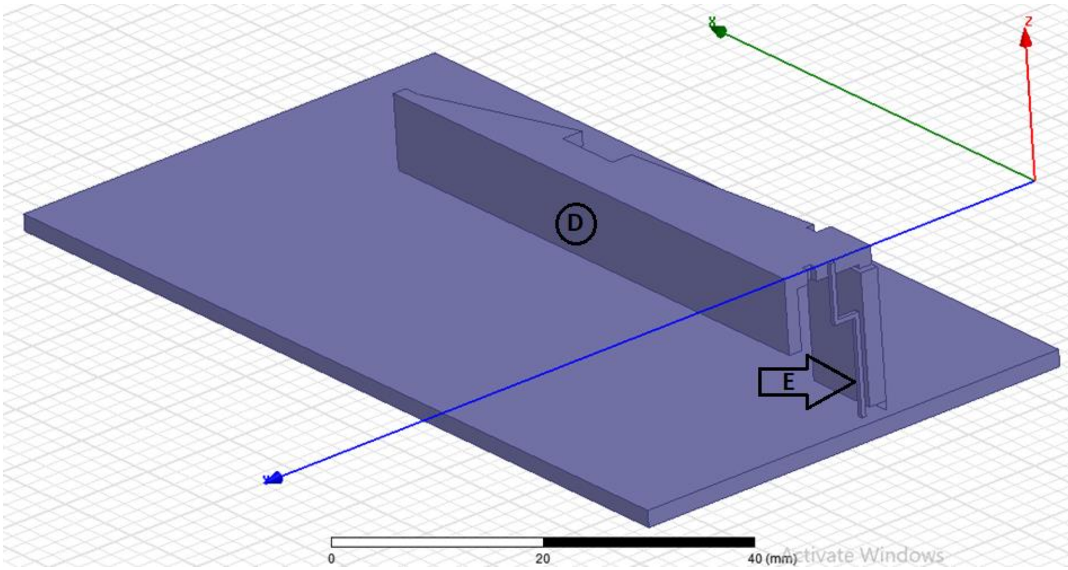
Thickness= 1.8 mm

The ground plane is made of copper substrate with the dimension as mention above and depicted in above figure. The dimensions of the ground is selected as such to achieve reduce return loss [16].

3.2.1.2 Dimensions of Planar Inverted F Antenna (PIFA):



(Fig 3.2 Dimensions of PIFA)



(Fig 3.3 Dimensions of PIFA)

A (Feeding Strip) = X size (8.5mm), Z Size (14.05mm)

B (Notch) = X size (7.53mm), Y size (2.33mm)

C (Feed) = X size (2mm), Z size (1mm)

D (Side) = X size (59.5mm), Z size (8mm)

E (Shorting Strip) = Y size (0.5mm), Z size (17mm)

The PIFA substrate is copper of 1.5mm thickness and above mention dimensions.

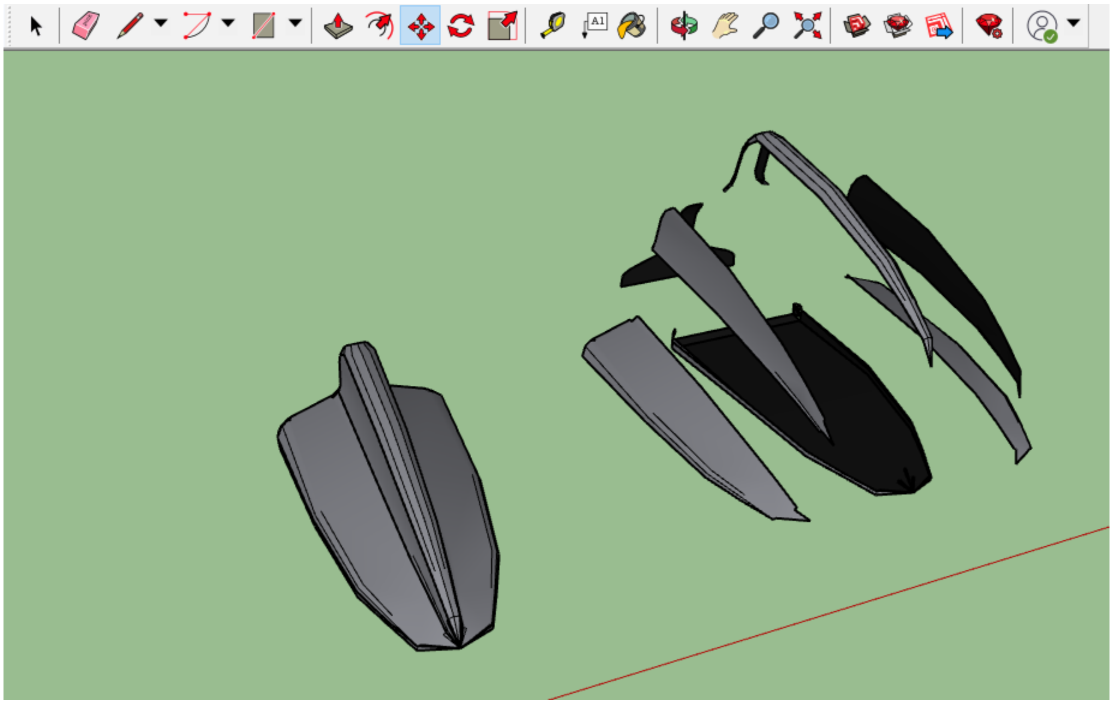
The feeding strip of the PIFA is designed on the mention dimensions which are connected to the feed point which is in turn itself touching the ground. The feed point of PIFA is not united with the strip and the ground plane [17].

While, the shorting strip, which is united with the PIFA, is made to touch the ground plane [18].

Upon, increasing the Z size of (D) side of PIFA, the return loss is altered. Thus Z size for (D) side is selected as 8mm to achieve the desired reduced return loss. To increase the operating frequency of the antenna, we can increase the length (Z Size) of the Shorting strip and Feeding strip of PIFA [19]. To achieve the modern frequencies of WiMAX/WLAN and LTE, we selected the length of Feeding strip as 14.05mm and Shorting Strip as 17mm [20].

The notch on the PIFA helps in minimizing the return loss to a great extent. The return loss also got reduced by increasing the size of ground plane and changing the position of PIFA on the ground plane. To achieve our frequencies, we selected the optimal dimensions and positions for the antenna [21].

3.2.2 Dimensions of Shark Fin Case:



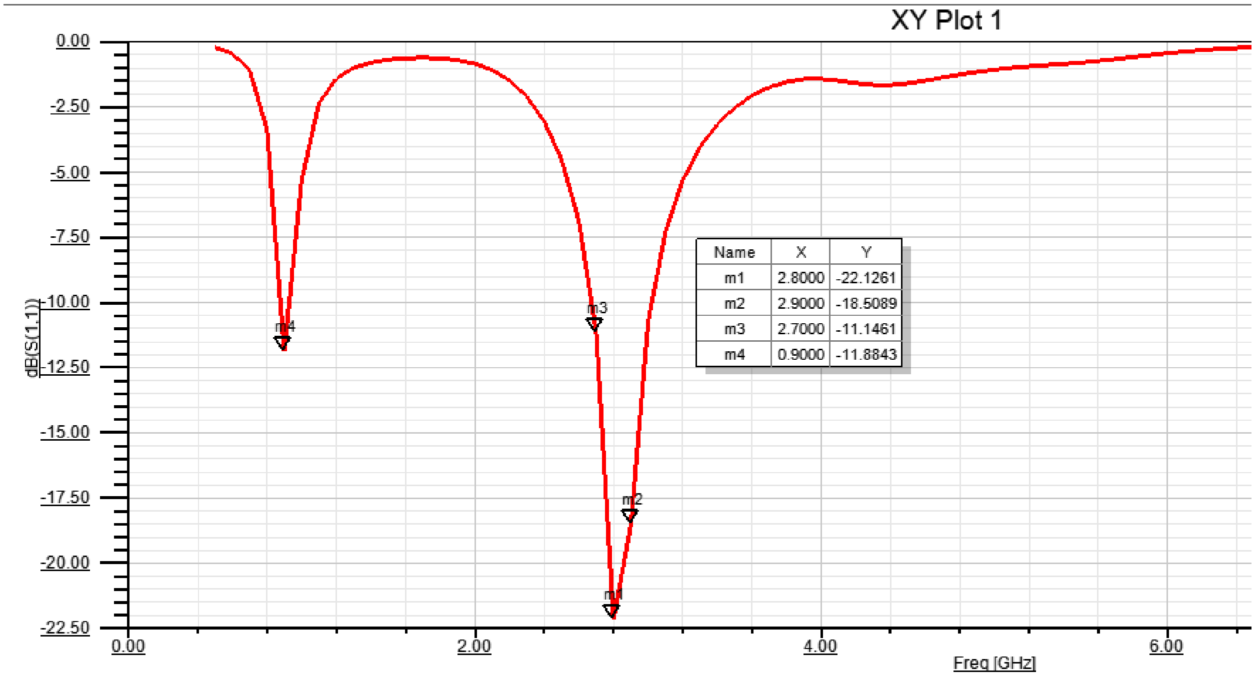
(Fig 3.4 Dimensions of Shark Fin case)

Width of Shark Fin case is 75 mm, height is 150 mm and length is 120 mm. The shark fin case is designed on SketchUp Pro 2020.

The Shark-fin case is made to accommodate the antenna within inside of it [22]. The above mentioned dimensions of case have been selected as it is larger than the antenna itself and can easily accommodate the antenna within itself. The case fabricated after the design is made of plastic material and colored to our own choice [23]. The shark-fin case designed has a hollow body with the shape of shark fin because it has better aerodynamic capabilities and provides lesser noise cancellations when antenna is enclosed in it.

4. Chapter 4: Antenna Results and Measurements

4.1 Return loss:



(Fig 4.1 Return Loss)

As seen from the required achieved results:

At 0.9 GHz, the return loss is -11.8843.

At 2.7 GHz, the return loss is -11.1461.

At 2.8 GHz, the return loss is -18.5089.

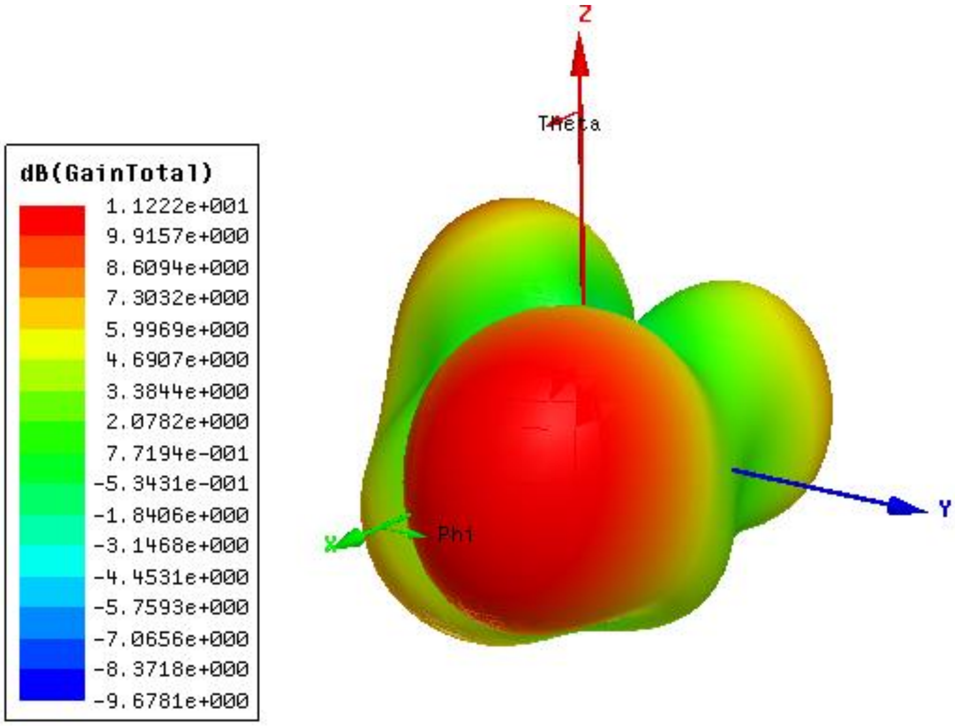
At 2.9 GHz, the return loss is -22.1261.

All the return losses for all the operating frequencies are less than -10 which is ideal and required.

The return loss of antenna at an operating frequency must be minimal for efficient communication as it provides a better resilience to the atmospheric cancellations when it is operated in real time. The achieved return loss for our antenna is all less than -10 for all frequency bands which our antenna is operated on which optimal for working when is put to test in real time [24].

4.2 Gain:

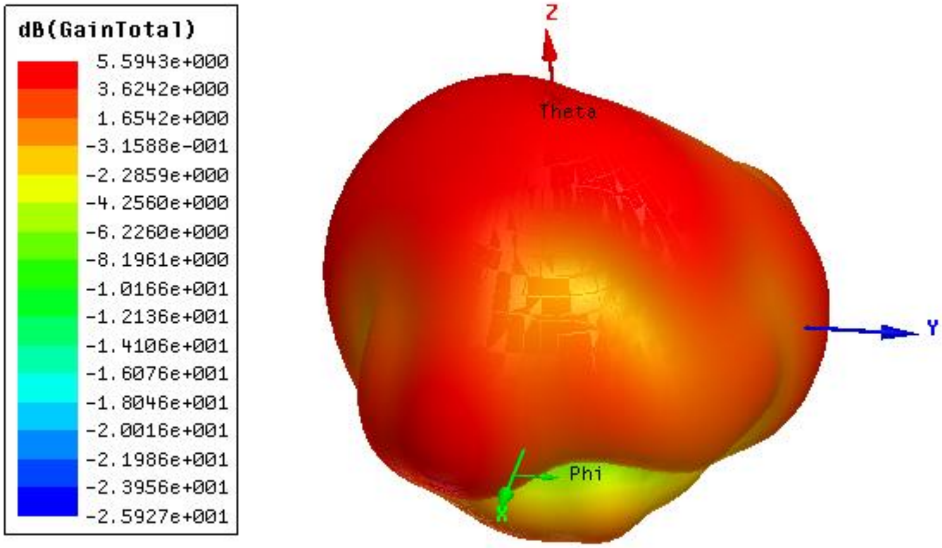
4.2.1 3D Plot



(Fig 4.2 Gain 0.9 GHz)

From the figure 4.2, it is visible that the gain at 0.9 GHz of operating frequency is positive and is equal to 11.222 dB and minimal at origin. As seen from the 3D plot, the shape of it is almost circular and it provides maximum gain the red colored area and minimum in blue colored [25]. The antenna almost provides equal gain in all directions.

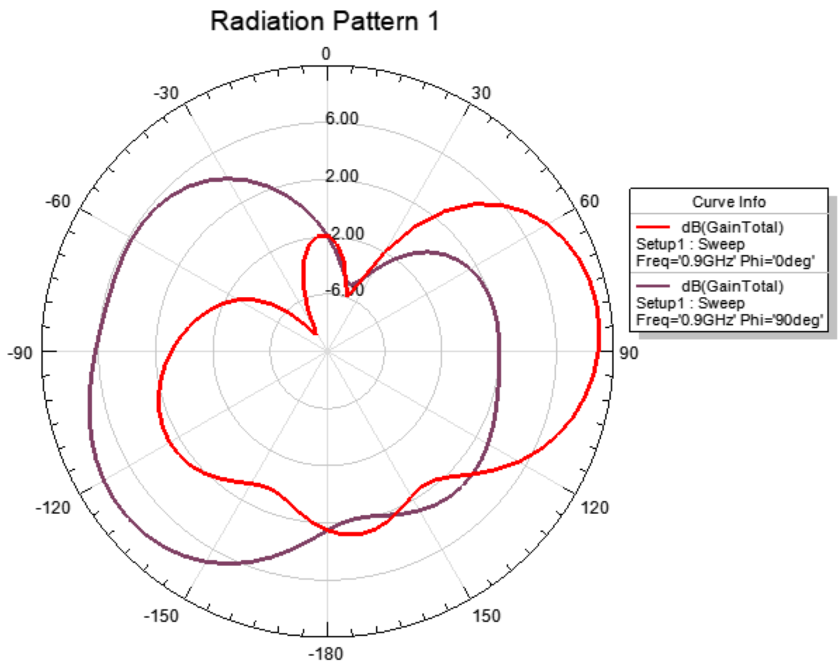
The spherical shape is an ideal case of isotropic antenna which exists in theories only. The real and non-ideal antenna does not have perfectly spherical 3d plot. The spherical shape of it means that the antenna radiates gain in directions equally [26]. The acquired 3d plot of antenna is close to spherical shape radiating maximum gain at red colored areas.



(Fig 4.3 Gain 2.8 Ghz)

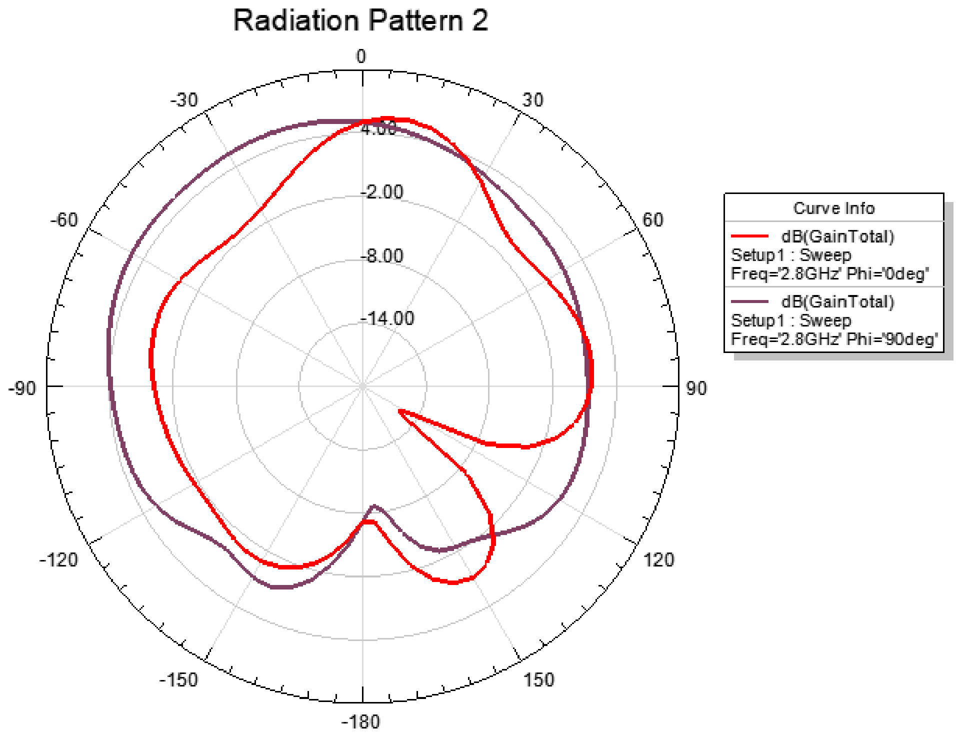
The gain at 2.8 GHz of operating frequency is 5.5943 dB and is positive. Thus the maximum gain is achieved.

4.3 Radiation pattern:



(Fig 4.4 Radiation Pattern 0.9 GHz)

Radiation pattern for 0.9 GHz for Phi= 0deg, 90deg is also achieved and is ideal for great for vehicular communication [27].



(Fig 4.5 Radiation pattern 2.8 GHz)

The radiation pattern for 2.8 GHz for phi= 0deg, 90deg, is visible in above mentioned figure. As seen, the power is almost is distributed evenly but still ideal nevertheless [28].

5. Chapter 5: Conclusion and Future Work

Previously the antenna had been operated on only FM and AM radio channels. Shark-Fin antenna will be fixed in a shark-fin case. The antenna designed operates on Long Term Evolution (LTE) and WiMAX/WLAN bands for vehicular communication. The designed antenna is with high positive gain and minimum return loss, efficient radiation pattern, and great isolation characteristics. The Shark-Fin antenna share information of traffic in the newly intelligent systems of transportation and telematics to avoid accidents involving traffic using LTE and WiMAX/WLAN communication bands for creating a safer driving environment [29].

In future, the antenna can be made into MIMO to increase the applications of the antenna and have it operate more efficiently to share traffic information for vehicular communication. The antenna can further be modified and edited to be operated on 5G modern bands [30].

6. References

[1] Smits. T., Suckrow. S., Christ. J., Geissler. M., "Active intelligent antenna system for car2car "International Workshop on Antenna Technology (iWAT), pp. 67-70, 2013.

[2] M. Gallo, S. Bruni, and D. Zamberlan, "A novel fully integrated fin antenna for automotive application ", 8th European Conference on Antennas and Propagation (EuCAP), pp. 2986-2989, 2014.

[3] H. J. Song *et al.*, "Evaluation of vehicle-level MIMO antennas: Capacity, total embedded efficiency, and envelope correlation," in *Proc. IEEE-APS Topical Conf. Antennas Propag. Wireless Commun.*, 2014, pp. 89–92.

[4] M. Geissler, K. Scharwies, and J. Christ, "Intelligent antenna systems for cars," in *Proc. German Microw. Conf.*, Aachen, Germany, 2014, pp. 1–3.

[5] D. V. Navarro-Mendez *et al.*, "Wideband double monopole for mobile, WLAN and C2C services in vehicular applications," *IEEE AntennasWireless Propag. Lett.*, vol. 16, pp. 16–19, 2017.

[6] Friedrich, B. Geck, O. Klemp, and H. Kellermann, "On the design of a 3-D LTE antenna for automotive applications based on MID technology," in *Proc. Eur. Microw. Conf.*, Nuremberg, Germany, 2013, pp. 640–643.

[7] N. Guan, H. Tayama, M. Ueyama, Y. Yoshijima, and H. Chiba, "A roof automobile module for LTE-MIMO antennas," in *Proc. IEEE-APS Topical Conf. Antennas Propag. Wireless Commun.*, Turin, Italy, 2015, pp. 387–391

[8] H. T. Chattha, Y. Huang, and Y. Lu, "PIFA bandwidth enhancement by changing the widths of feed and shorting plates," *IEEE Antennas Wireless Porpag. Lett.*, vol. 8, pp. 637–640, 2009..

[9] R. G. Vaughan and J. B. Andersen, "Antenna diversity in mobile communications," *IEEE Trans. Veh. Technol.*, vol. VT-36, no. 4, pp. 149–172, Nov. 1987.

[10] D. N. Aloi, M. Possa, A. Barghouti, J. Tlusty, and M.S. Sharawi, "Printed DSRC antennas for enhanced gain coverage towards front and rear of vehicle for automotive applications," in IEEE-APS Topical Conf. Antennas Propag. Wireless Communications, Aug. 3-9, 2014, pp. 349-352.

[11] J. Härri, H. Tchouankem, O. Klemp, and O. Demchenko, "Impact of vehicular integration effects on the performance of DSRC communications," in IEEE Wireless Communications Networking Conf., Apr. 7-10, 2013, pp. 1645-1650.

[12] W. Viriyasitavat, M. Boban, H. M. Tsai, and A. Vasilakos, "Vehicular communications: survey and challenges of channel and propagation models," IEEE Veh. Tech. Mag., vol. 10, no. 2, pp. 55-66, Jun. 2015.

[13] P. Papadimitratos, A. D. La Fortelle, K. Evenssen, R.Brignolo, and S. Cosenza, "Vehicular communication systems: enabling technologies, applications, and future outlook on intelligent transportation," IEEE Communications Mag., vol. 47, no. 11, pp. 84-85, Nov. 2009.

[14] Malarky, G. Z. Rafi, S. S. – Naeini, “A planar dual band GPS and DSRC antenna for road vehicles”, Vehicular Technology Conference, 2007, VTC-2007, Fall 2007 IEEE 66th, Baltimore, MD, pp. 2096-2100, Sept30 2007 – Oct3 2007.

[15] ASTM 2213-03, Standard Specification for Telecommunications and Information Exchange Between Roadside and Vehicle Systems – 5GHz Band Dedicated Short Range Communications (DSRC) Medium Access Control (MAC) and Physical Layer (PHY) Specifications.

[16] Cseh, C., ‘Architecture of the dedicated short-range communications (DSRC) protocol”, Vehicular Technology conference, 1988, VTC 98 48th IEEE, vol 3 pp 2095-2099.

[17] H. Miyazaki, K. Sakaguchi, “A study on the shape of ground plane of fin-type wide-band antenna,” *Proc. IEICE Society Conf*. B-1-157, 2008.

[18] K. Iigusa, H. Harada, “Wideband planar bent monopole antenna and basic study” *Proc. IEICE General Conf*. B-1-56, 2014.

[19] K. L. Wong, Planar Antennas for Wireless Communications. New York: Wiley, 2003.

[20] Y. Du, A. Zhao, A. Salo, and J. Saunamaki, "Bandwidth potential analysis of GSM antennas based on oval-shaped mobile terminals," in *Proc. ICMMT, Chengdu, China, May 2010*, pp. 4-7.

[21] K. L. Wong and Y. C. Lin, "Thin internal planar antenna for GSMIDCSIPCSIUMTS operation in a PDA phone," Microw. Opt. Techno!. Lett., vo!' 47, No. 5, pp.423-426, Dec.5, 2005.

[22] Kin-Lu Wong, "Design of nonplanar micros trip antenna and transmission lines," John Wiley and Sons, Inc, 1999.

[23] HM.Chen and K.L.Wong, "Characterization of couped cylindrical microstriplines mounted inside a ground cylinder," Microwave Opt. Techno!. Lett., vo!' 10, pp. 330-333, Dec. 20, 1995.

[24] IHLu and K.L.Wong, "Analysis of slot-couped double-sided cylindrical microstrip lines," IEEE Trans. Microwave Theory Tech., vo!' 44, pp.1l 67-1170, July 1996.

[25] IIAdams, S.C.Slimmer,T.F.Malkowski, and E.B.Duoss, etc, "Comparison of spherical antennas fabricated via conformal printing: helix, meanderline, and hybrid designs," IEEE Antennas and Wireless Propagation Letters, vo!' 10, pp.1425-1428, Dec, 2011.

[26] A. Duzdar, C. Thiam, “Integrating V2V funtionality at 5.9GHz into an existing quad-band antenna for automotive applications”.

[27] M. A. Bueno Diez and S. Lindenmeier, “A highly efficient Car2Car-multiband rooftop automotive antenna,” in IEEE Int. Symp. Antenna Propag. USNC/URSI National Radio Science Meeting, Jul. 19-24, 2015, pp. 1606 - 1607.

[28] L. Ekiz, T. Patelczyk, O. Klemp, and C. F. Mecklenbräuker, “Compensation of vehicle-specific antenna radome effects at 5.9 GHz,” in 39th Annual Conf. IEEE Ind. Electron. Society, Nov. 10-13, 2013, pp. 6880-6884.

[29] M. M. Fakharian, P. Rezaei, and A. Azadi, “A planar UWB bat-shaped monopole antenna with dual bandnotched for WiMAX/WLAN/DSRC,” Wireless Personal Communications, vol. 81, no. 2, pp. 881-891, Mar. 2015.

[30] A. Thiel, L. Ekiz, O. Klemp, and M. Schultz, “Automotive grade MIMO antenna setup and performance evaluation for LTECommunications”, International Workshop on Antenna Technology (iWAT), pp.171-174, 2013.

Shark Fin Antenna

by Maryam Rasool

Submission date: 03-Jul-2020 03:42PM (UTC+0500)
Submission ID: 1352978589
File name: Shark_Fin_Antenna.docx (1.14M)
Word count: 3142
Character count: 17589

Shark Fin Antenna

ORIGINALITY REPORT

9%	3%	2%	8%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to Higher Education Commission Pakistan Student Paper	1%
2	Submitted to University of Liverpool Student Paper	1%
3	Submitted to Macquarie University Student Paper	1%
4	/paperInfo.asp?oid=6508106 Student Paper	1%
5	M.F. Caggiano, J. Ou, S. Bulumulla, D. Lischner. "RF electrical measurements of fine pitch BGA packages", IEEE Transactions on Components and Packaging Technologies, 2001 Publication	1%
6	Submitted to Bolton Institute of Higher Education Student Paper	<1%
7	core.ac.uk Internet Source	<1%

8	Submitted to Hong Kong Baptist University Student Paper	<1%
9	dx.doi.org Internet Source	<1%
10	Submitted to The Hong Kong Polytechnic University Student Paper	<1%
11	Submitted to Kumoh National Institute of Technology Graduate School Student Paper	<1%
12	usir.salford.ac.uk Internet Source	<1%
13	Amandeep Singh, Surinder Singh. "A trapezoidal microstrip patch antenna on photonic crystal substrate for high speed THz applications", Photonics and Nanostructures - Fundamentals and Applications, 2015 Publication	<1%
14	Submitted to Wawasan Open University Student Paper	<1%
15	Submitted to University of Bedfordshire Student Paper	<1%
16	Submitted to Universiti Teknologi Malaysia Student Paper	<1%

17	Submitted to University of Bristol Student Paper	<1%
18	Submitted to University of Hong Kong Student Paper	<1%
19	Submitted to City University of Hong Kong Student Paper	<1%
20	scholar.lib.vt.edu Internet Source	<1%
21	Submitted to University Der Es Salaam Student Paper	<1%
22	eprints.nottingham.ac.uk Internet Source	<1%
23	repository.kulib.kyoto-u.ac.jp Internet Source	<1%
24	amandala.com.bz Internet Source	<1%
25	Submitted to University of Newcastle upon Tyne Student Paper	<1%
26	Submitted to Universiti Teknologi MARA Student Paper	<1%
27	"Proceeding of the International Conference on Computer Networks, Big Data and IoT (ICCBI - 2018)", Springer Science and Business Media LLC, 2020	<1%

Publication

Exclude quotes	Off	Exclude matches	Off
Exclude bibliography	Off		

Shark Fin Antenna

GRADEMARK REPORT

FINAL GRADE

/0

GENERAL COMMENTS

Instructor

PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5

PAGE 6

PAGE 7

PAGE 8

PAGE 9

PAGE 10

PAGE 11

PAGE 12

PAGE 13

PAGE 14

PAGE 15

PAGE 16

PAGE 17

PAGE 18

PAGE 19

PAGE 20

PAGE 21

PAGE 22

PAGE 23

PAGE 24