5G Antipodal Reconfigurable Base Station Antenna for Modern automobile tracking applications

S Satheesh Kumar¹, V D Rithanesh², K Sharan² and T Sidharth²

¹Assistant Professor, Department of Electronics and Communication Engineering, KPR Institute of Engineering and Technology, Coimbatore, Tamil Nadu, India.
²UG Scholars, Department of Electronics and Communication Engineering, KPR Institute of Engineering and Technology, Coimbatore, Tamil Nadu, India.

Abstract. This paper presents antipodal dipole antenna which is also a base station antenna which is highly suitable for tracking an automobile especially cars/trucks. This antenna contains 4 planes, including the reflector plane, brick on which two poles are present. The Gain of the antenna is around 6.9 to 7.1 dB based on the width of the dipole of the antenna. The directivity remains the same in all width of the dipoles and the S11 parameters values changes as of the width of the dipole. Comparatively the antenna has a good gain and S11 values in frequency 6.5 GHz at the dipole width of 4mm. This antenna finds its way in medical fields to improve the communication inside the automotive vehicles. The proposed antenna is a reconfigurable antenna, which has good gain at multiple frequencies. The reconfigurable is made possible using Metamaterials. The Antipodal structure of the antenna is due to presence of multiple planar types in the antipodal structure of the antenna. Even if the frequency not properly received by the antenna, the reflector plane reflects the frequency towards the one plane at the back of the brick, so the gain is maintained at a desired level.

Keywords: Antipodal antenna, Reconfigurable antenna, Multi Planar structures, Automobile tracking

1. Introduction

The recent developments in mobile technology and communication advancements have paved way for higher data rates. Most of the people have smartphones and each person consume about 11 gigabytes a month on an average. The increase in the media consumption such YouTube, OTT platforms and music platforms. The resolution of the videos and device on which they are viewed are increasing. For a 4K video, a device need a data rate of 15.4 Mbps [1]. Most of the TV programs are viewed online and every working person will enjoy the pleasure of watching their favourite shows at desired time. The Annual traffic of data is increasing exponentially and there is need for increased bandwidth. Evolution of 5G will act as a solution for these problems [2].

5G is around the corner and its implementation for public use will boost the data rates and reduce the latency to 1ms so that people can experience a delay free internet in every nook and corner of their country. 5G works on millimetre wave (mmW) technology, due to which they cannot travel long distances but it has larger bandwidth resulting in connecting millions of devices [3]. 5G is also backward compatible supporting
4G. The Millimetre wave (mmW) cannot pass through building walls. 5G can be helpful in overly crowded places such as Stadiums, Cities etc. 5G with IOT can help in lot of monitoring activities such as air pollution level in different parts of country, Health monitoring from homes, autonomous cars, locating parking spaces to a lot of different other purpose. Most antenna in the real world, which are locked to a certain frequency and they cannot well work with other frequencies and bandwidths. The proposed antenna has a nature to work according to the frequency received. This is the reconfigurable property of the antenna, which is attained using metamaterials and switches [4]. This antenna can be used for all modern applications. Reconfigurable antennas can helpful where there a space constraint. Since this antenna has 4 planar antennas in a single antenna structure, it can be used as a base station antenna. It is comparatively smaller than Array antenna and can be placed in the smallest area available. The antenna works in UWB (Ultra wide band)[5] frequency, since UWB signals can be identified even in a noisy environment.

2. Literature Review

2.1 A survey of the challenges, opportunities and use of multiple antennas in current and future 5G small cell base station [2016]
This paper highlights the challenges and opportunities faced while deploying the small base stations and multiple array antennas for 5G. Its gives an insight on Femtocell SBS (Small cell Base Stations). The design challenges, beam forming etc. are discussed. Since 5G is based on millimetre waves which cannot penetrate through walls and certain other objects. The paper deals with the above mentioned objectives

2.2 5G: A tutorial overview of standards, trails, challenges, deployment and practice [2017]
This paper lays a solid foundation on 5G, its requirements, spectrum regulation, standardization, technologies required for RF Interfaces, Channel characteristics, Signal processing techniques, waveform and channel access, core network and cloud RAN Architecture and Deployment.

2.3 Reconfigurable magneto-electric dipole antennas for base stations in modern wireless communication systems:[2018]
This paper proposes the concept of Magneto-electric (ME) dipole antenna with the functions of changing the frequency, polarizations etc. The reconfigurability nature of the antenna can provide it the power to alter according to the function for it is required. The reconfigurability is achieved through electrically altering the states of diode, varactors. The reconfigurable nature helps to increase communication efficiency, and it comes in lower price range compared to designing antenna for various purposes.

2.4 Compact base station antenna based on image theory for UWB/5G RLTS embraced smart parking of driverless cars: [2019]
This paper presents an antenna which has enhanced directivity/gain for UWB RLTS (Real Time Locating Service) applications. This is an antipodal dipole antenna with poles printed on both sides of Roger4350B substrate. The antenna can be used for locating parking spaces for autonomous cars in the cities. This paper proposes a concept of decimetre locating for accuracy of the location for autonomous cars. The antenna has a half power beam width of 110° and a 7 dB gain.

2.5 Reconfigurable antennas: switching survey [2020]
This paper highlights on the techniques by which the reconfigurable nature can be bring upon antennas. The methods suggested are electrical reconfiguration which uses switching components like PIN Diodes, varactors or MEMS. Other method was Optical reconfiguration which are made of photo configuration cells. Other method is Mechanical reconfiguration method in which the antenna can be physically reconfigured to provide different characteristic. Another method is to reconfigure using smart materials i.e. metamaterials. The paper suggests that the type of reconfigurability required is based on the type of application the antenna is used for.
2.6 A graphene-based multiband antipodal vivaldi nano antenna for UWB applications [2020]
This paper proposes a Graphene based Vivaldi antenna which has features like high directivity and return loss with good bandwidth and reasonably good gain. The proposed antenna has use in medical field for detection of brain tumour. It’s a multiband antenna used in THz frequency range using co- and cross-polarization.

3. Antipodal antenna for wireless application

The Antenna is an Antipodal dipole antenna for 5G purpose. This antenna is based on UWB for RLTS [Real Tine Location System] [6] application with a gain of 7 dB and directivity of 110°. The RLTS system proposed by them is in decimetre range whereas systems now-a-days use meter level range. This antipodal dipole structure has 4 planar antenna. First two planes of length and width 7.95mm and 2mm respectively which are placed on both the sides of the brick that is made of Rogers4350B substrate. The third planar is a reflector plane of length and width of 30mm and 20 mm, which is also made of Rogers4350B Substrate. The fourth planar structure is the plane on which the two planes are placed on. The reflector plane and brick on which the two planes are placed are separated by a ABS plastic column of length 8mm Figure 1-6.

![Figure 1: Designed Antipodal Antenna.](image1)

![Figure 2: Mesh Design with various dimensions.](image2)
The designed Antipodal antenna has dimensions, \( W=20\text{mm} \), \( L=30\text{mm} \), \( W_2=2\text{mm} \), \( W_1=4\text{mm} \), \( L_1=7.95\text{mm} \), \( H_2=0.8\text{mm} \), \( H_1=8\text{mm} \). The Antenna is designed and simulated using software specifically designed to simulated antenna design [7-12]. The gain of the antenna is really high at 7 dB and producing a directivity of 110°.

**Figure 3:** Side View of the designed Antipodal antenna.

**Figure 4:** Gain of Antenna at 6.5GHz

**Figure 5:** S11 Characteristics of designed antenna.
By varying the sizes of the two poles, which are placed on the either sides of the brick. The results parameters are varied. These results are taken with the width of the poles are changed to 3mm. in figure 7-9.

**Figure 6**: 3D view of Directivity of the antenna

**Figure 7**: Gain of the antenna at 6.5GHz for pole width of 3mm.

**Figure 8**: S11 Characteristics for pole width of 3mm.
By varying the sizes of the two poles, which are placed on the either sides of the brick. The results parameters are varied. These results are taken with the width of the poles are changed to 4mm in figure 10-12.

Figure 9: 3D view of Directivity at 6.5GHz for pole width of 3mm.

Figure 10: Gain of the antenna at 6.5GHz for pole width of 4mm.

Figure 11: S11 characteristics of antenna at 6.5GHz for pole width of 4mm.
Figure 12: 3D View of Directivity of antenna at 6.5GHz for pole width of 4mm.

By varying the sizes of the two poles, which are placed on the either sides of the brick. The results parameters are varied. These results are taken with the width of the poles are changed to 5mm in figure 13-15.

Figure 13: Gain of the antenna at 6.5GHz

Figure 14: S11 characteristics of antenna at 6.5GHz
The proposed antenna is a reconfigurable antenna, which has good gain at multiple frequencies. The reconfigurable is made possible using Metamaterials. The Antipodal structure of the antenna is due to presence of multiple planar types in the antipodal structure of the antenna. Even if the frequency not properly received by the antenna, the reflector plane reflects the frequency towards the one plane at the back of the brick, so the gain is maintained at a desired level.

4. Conclusion

This paper presents a antipodal dipole antenna which is also a base station antenna. This antenna contains 4 planes, including the reflector plane, brick on which two poles are present. The Gain of the antenna is around 6.9 to 7.1 dB based on the width of the dipole of the antenna. The directivity remains the same in all width of the dipoles and the S11 parameters values changes as of the width of the dipole. Comparatively the antenna has a good gain and S11 values in frequency 6.5 GHz at the dipole width of 4mm. This antenna finds its way in medical fields to improve the communication inside the automotive vehicles.

References

[1] Abubakar Sharif, J Guo, J Ouyang, S Sun, K Arshad, M Ali Imran, Qammaer H. Abbasi 2020 Compact base station antenna based on image theory for UWB/5G RTLS embraced smart parking of Driverless cars. IEEE Access
[2] Lei Ge, X Yang, Z Dong, D Zhang, Xierong Zeng 2018 Reconfigurable magneto-electric dipole antennas for base stations in modern wireless communications systems. Hindawi -Wireless Communications and Mobile Computing.
[3] Gaurav Bansal, Anupma Marwaha, Amanpreet Sigh 2019 A graphene-based multipband antipodal Vivaldi nanoantenna for UWB applications. Journal of computational electronics
[4] Naser Ojaroudi Parchin, H.J.Basherlou, Yasir I.A. Al-Yasir, Ahmed M. Abdulkhaleq and Raed A. Abd-Alhameed 2017 Reconfigurable Antennas: Switching techniques- A Survey. Electronics journal
[5] M. Sha_, A. F. Molisch, P. J. Smith, T. Haustein, P. Zhu, P. De Silva, F. Tufvesson, A. Benjebbour, and G. Wunder 2017 5G: A tutorial overview of standards, trials, challenges, deployment, and practice. IEEE J. Sel.Areas Communication.
[6] D. Muirhead, M. A. Imran, and K. Arshad, 2016 A survey of the challenges, opportunities and use of multiple antennas in current and future 5G small cell base stations. IEEE Access.
[7] Mydavolu Venkata Abhijith S.Satheesh Kumar, Poorna Pushkala , M.Renuka, Muthuraman 2017 Li-Fi Based High Data Rate Visible Light Communication for Data and Audio Transmission. International Journal of Electronics and Communication Engineering
[8] S. Satheesh Kumar, J. L. Mazher Iqbal, J. S. Sujin, R. Sowmya, D. Selva Kumar 2019 Recent Advancements in Automation to Enhance Vehicle Technology for Human Centred Interactions.
[9] Satheesh Kumar S Muruganandham A Shobana Priya M S, Manikandan T, Joshua Kumaresan S 2019 Implementation of Low Power and Area Efficient Vedic Multiplier. International Journal of Innovative Technology and Exploring Engineering (IJITEE)

[10] D. Devikanniga, A. Ramu, and A. Haldorai, Efficient Diagnosis of Liver Disease using Support Vector Machine Optimized with Crows Search Algorithm, EAI Endorsed Transactions on Energy Web, p. 164177, Jul. 2018. doi:10.4108/eai.13-7-2018.164177

[11] H. Anandakumar and K. Umamaheswari, Supervised machine learning techniques in cognitive radio networks during cooperative spectrum handovers, Cluster Computing, vol. 20, no. 2, pp. 1505–1515, Mar. 2017S. Satheesh Kumar, R. Sowmya, B. Maruthi Shankar, N. Lingaraj and S.A. Sivakumar 2021 Analysis of Connected Word Recognition systems using Levenberg Marquardt Algorithm for cockpit control in unmanned aircrafts. Materials Today: Proceedings